AIRCRAFT & MISSILES

Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES August 1960

How GSE Keeps Hustler Mission-Ready... P 50

THE HARNESS THAT HOLDS POLARIS... P 22

Grumman's A2F-1—ANIP Gives Birth... P 38

Mark 3 Meets Missile Via GSE... P 17

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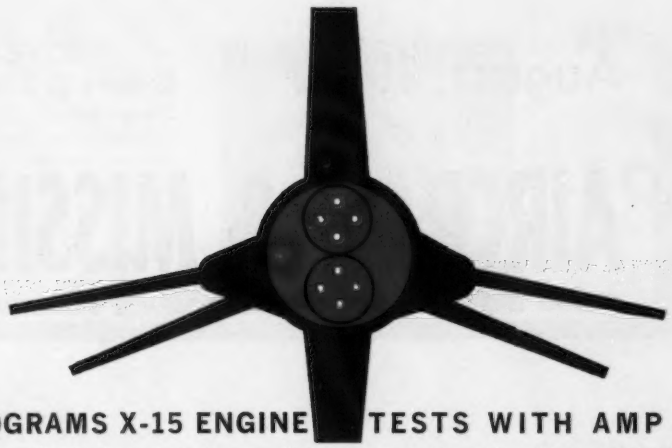
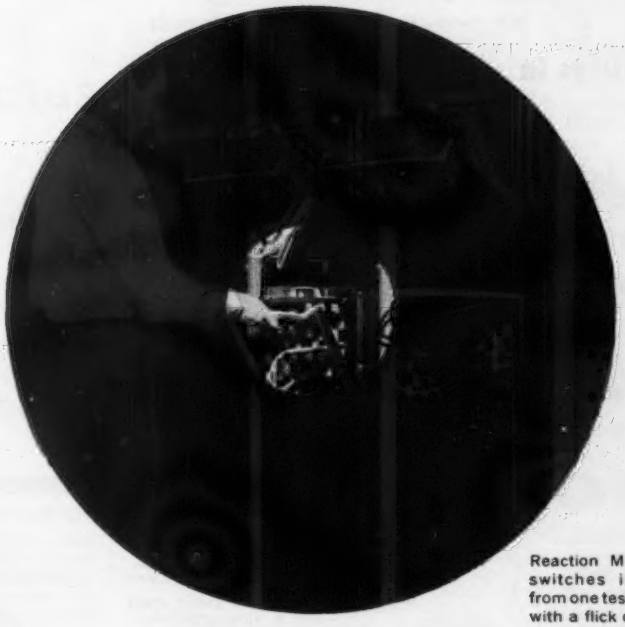


Thiokol PROGRAMS X-15 ENGINE TESTS WITH AMP PATCHBOARDS

To test the 50,000 pounds of whoosh in its new X-15 engine, Reaction Motors Division of Thiokol Corporation required versatile and reliable programming systems to connect instrumentation to six different test stands. With the assistance of AMP engineers, Thiokol installed six patchboard programming systems that can connect one set of test instruments of any of six test stands with a flick of the wrist—a saving of time, personnel and equipment. In addition to tremendous flexibility, AMP systems—either universal or shielded—provide a number of exclusive features including pre-cleaning of contact pins and springs, rugged take-a-beating construction, an almost unlimited range of sizes, plus electrical characteristics suited to the most sensitive applications—all contributing to top notch reliability. **For the complete story, write for our Patchcord Programming Catalog.**



Reaction Motors' technician switches instrumentation from one test stand to another with a flick of the hand.

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GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

←——Circle 1 on Inquiry Card

Circle 4 on Inquiry Card

August, 1960 *Volume 3, Number 8*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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THE COVER STORY

The first Atlas missiles to have a degree of protection from enemy bomb blasts will be stored and serviced in horizontal "coffins." Special ground support trailers have been built to bring the nose cone (reentry vehicle) to the missile. Shown at Warren AFB is a General Electric Mark 3 nose cone being mated to an Atlas in its "coffin." Trailer can also handle Avco-built Mark 4 nose cone. See page 17.

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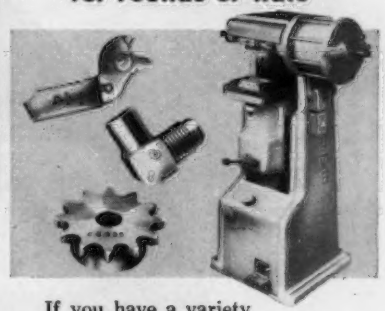
for rounds or flats



If you have a variety of shapes to mark, write for Bulletin FGP 20. Full description of Matthews General Purpose Machines.

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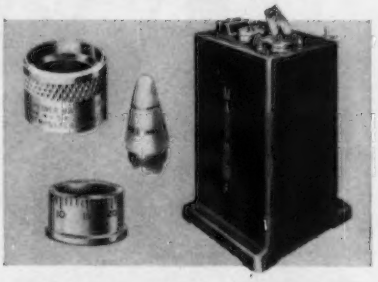

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RAVENNA, OHIO

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Less Publicity

Mobility, that's the keynote. Get mobility into our missile systems. Keep them moving. Defense chiefs talk mobility, but give their weapons little.

Seems like the publicity campaigns are much more mobile than the armament. A case in point is the recent Air Force rush for press notice on the Minuteman train "mobile system." Air Force showed a train. Most people have seen one before. Missing were the Minuteman missile, the launching car, and the missile control mechanism. In short, Air Force showed a train owned by the taxpayers. Is this the last word of "mobility"?

This may be beyond DOD thinking, but what is true mobility? By definition, anything that is movable can be said to possess a degree of mobility. Such things as aircraft, trucks, and trains are dependent on fixed support. Each must operate between fuel and supply depots. In the case of a train, its path remains fixed. At least trucks and aircraft might have depot selection. These units are movable but do not possess the characteristics of true mobility.

In true mobility, units must be self supporting for extended time periods. Perhaps, only one of our services really possesses that one characteristic. That service, the Navy, can operate in task force over 70 per cent of the earth's surface in an infinite number of routes.

Mobile Minuteman

Too Little Too Soon

Navy's aircraft carriers and Polaris-launching, nuclear submarines meet the criteria of constant movement with a self-sufficiency over prolonged periods.

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Tom MacNew

Editor

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August 1-3
Fourth Global Communications Symposium
IRE, Army Signal Corps
Statler Hilton, Washington, D. C.

August 8-10
1960 Meeting
Asso. of the U. S. Army
Washington, D. C.

August 8-11
Western National Meeting
American Astronautical Society
Olympic Hotel, Seattle, Wash.

August 14-17
4th National Heat Transfer Conference and Exhibit
ASME, AICE
Statler Hilton, Buffalo, N. Y.

August 15-20
Annual Congress
International Astronautical Federation
Royal Institute of Technology, Stockholm, Sweden

August 18-19
International Symposium on Submarine and Space Medicine
Laboratory of Aviation and Naval Medicine
Karolinska Institute, Stockholm

August 23-25
1960 Cryogenic Engineering Conference
University of Colorado, Boulder, Colo.

August 23-26
Western Electronic Show and Convention
IRE
Ambassador Hotel, Los Angeles

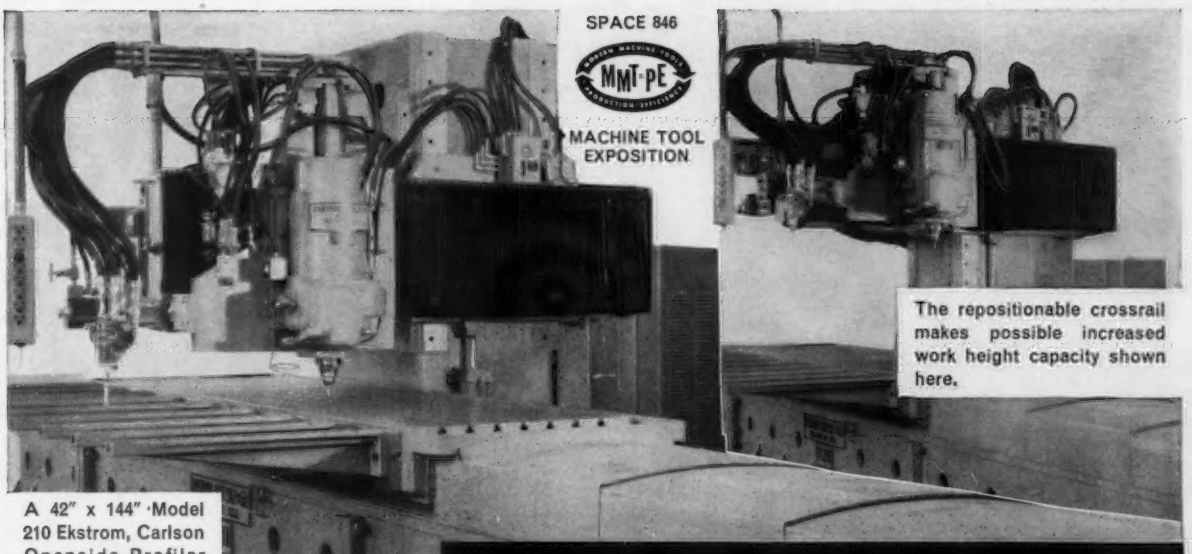
September 5-11
1960 Farnborough Show
Society of British Aircraft Constructors
Farnborough, Eng.

September 6-16
The Machine Tool Exposition—1960
National Machine Tool Builders Asso.
International Amphitheatre, Chicago

SPACE 846

MMT-PE

MACHINE TOOL EXPOSITION

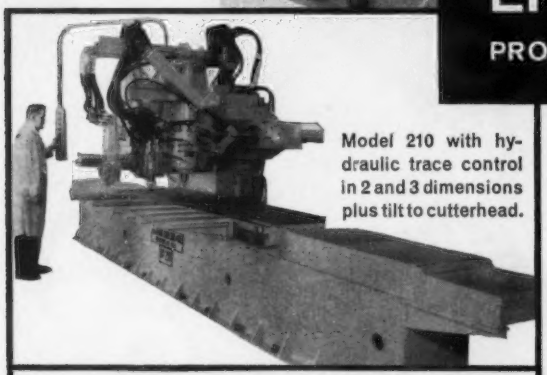


A 42" x 144" Model 210 Ekstrom, Carlson Openside Profiler with 3 dimension trace control.

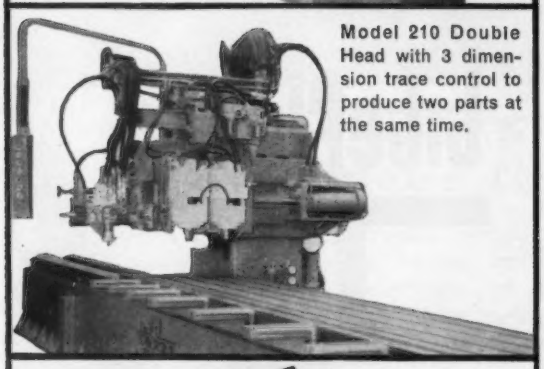
The repositionable crossrail makes possible increased work height capacity shown here.

EKSTROM, CARLSON

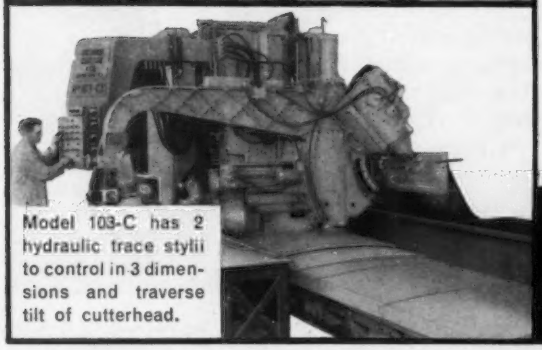
PROFILE AND CONTOUR MILLING MACHINES



Model 210 with hydraulic trace control in 2 and 3 dimensions plus tilt to cutterhead.



Model 210 Double Head with 3 dimension trace control to produce two parts at the same time.



Model 103-C has 2 hydraulic trace stylii to control in 3 dimensions and traverse tilt of cutterhead.

. . . . from small to large

Openside or Bridge Type
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**T.M. of Titeflex, Inc., Pat. Pend.

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Circle 24 on Inquiry Card →

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Reader's Orbit

Vibration Problems

. . . We note in the April, 1960, issue of Aircraft and Missiles the nomographs presented on pages 51 and 52 which allows one to determine the natural frequency of circular steel plates and also the frequency conversion nomograph for converting from steel to other metal, also in circular plates . . . can the writer obtain either three or five copies of this reprint?

Also, could we have the complete address of Dr. Robert L. Peters, Chief Engineer of the Neo Company? We should like very much to contact him regarding our lead/vinyl acoustical weights from 2 lbs/sq yd (0.3 lbs/sq ft) up to 6 lbs/sq ft, in tile form. If he has vibration damping problems, these materials could prove of prime interest to him.

F. M. Hall, Sales Manager
Thermoplastics Div.
Cordo Chem. Corp.

Dr. Peters can be reached at 2973 Riverside Blvd., Sacramento, Calif.

P. S. From An Author

. . . In your May 1960, issue you published an article by Mr. Kleint and myself entitled "Testing Solid-Propellant Rocket Motors." Congratulations on doing a fine job (of editing).

Unfortunately, I do not get your publication so I have no copy of the article. I would appreciate a few copies of the entire magazine, and also as many reprints as you can spare.

. . . would appreciate having the Paramount Division of Automation Industries, Inc., placed on your mailing list.

R. D. McKown
Research Engineer
Automation Industries, Inc.

PS. Incidentally, the author's names on the subject article are KLEINT and McKOWN, not Klient and McCown.

On File At Marquardt

. . . Aircraft & Missiles occupies a top spot in our Pomona Div. Library (Marquard't) as much used and highly valued publication. I particularly liked "Vicious Procurement Practices In DOD?" in the current issue. It's very much to the point.

J. A. Moreno
Engineering Admin.
The Marquardt Corp.

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handles more air...with minimum pressure drop
– and gives you all these other advantages–

Has fewer parts. Locking ring provides positive lock . . . tight fit . . . minimum wear. Equipped with automatic sleeve lock.

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Shelter for "Hawk" Missile System

8893-AC

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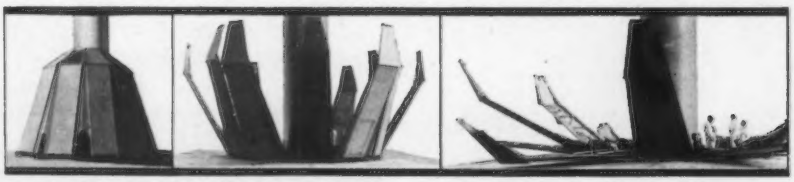
ANOTHER CURRENT GSE PROJECT AT AERONCA . . .



These photos show performance tests on a production model of new tactical shelter for "Jupiter" IRBM.

AERONCA

manufacturing corporation

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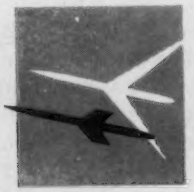
Openings for creative R&D Engineers with Missile-Space experience. Write to O. E. Chandler, Mgr. Professional Employment.

Data Capsule



SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES

MISSILES AND SPACE VEHICLES

Design

TITAN II will employ storable liquid fuel. Present Titan uses lox and kerosene-type fuel. Storables will allow the missile to be fired from within its silo instead of being raised to the surface. First six Titan squadrons will have the old fueling system. Next four will have Titan II.

NEW PROPULSION SYSTEM proposed by Rocketdyne would propel target drones at Mach 2. System would use firm's variable area nozzle. Propellant would be ammonium nitrate. Max. altitude: 70,000 ft.

Development

SPACE R & D will be managed for the Air Force by the new non-profit Aerospace Corp. Firm will take over defense work of Space Technology Laboratories except for Atlas, Titan, and Minuteman. STL will now follow normal competitive contractual procedures.

TITAN LAUNCHING SYSTEMS will be produced and installed by American Machine and Foundry Co. Four squadrons will have nine launcher systems each.

FIRST MINUTEMAN BASE, at Malmstrom AFB, Mont., will have 55 missiles. Underground launch silos here are to be completed by the Summer of 1962. Current missile train tests are determining control for mobile squadrons. First such mobile unit will contain ten trains. Eventually, 450 Minutemen may be in hard sites, with 150 more on 50 missile trains.

WORK COMMENCING on advanced "hard" Atlas bases. These will have 12 launchers each instead of nine.

FIRST ABLATION-TYPE "NERV" is slated to be boosted 1200-1500 miles high this month from Pt. Arguello, Calif. This is highest point from which re-entry and recovery has ever been attempted. Blunt "Nuclear Emulsion Radiation Vehicle" was developed by General Electric to provide most complete measurements yet of the Van Allen belts. It will be boosted by D-8 Journeyman rockets (Aerolab Development Co.) Scout boosters may be used in 1961.

IMPROVED TARTAR will use high energy solid propellant.

RE-ENTRY "DRAG" BALLOONS will be tested this Summer with Cree missiles. Tests are slated to reach Mach 3 and 200,000 ft. The coated-fabric balloons, developed by Goodyear Aircraft, may be used to slow space vehicles.

MINUTEMAN THIRD STAGE ROCKET MOTORS have been test-fired at Aerojet-General Corp. and Hercules Powder Co. Aerojet's has a titanium casing. The Hercules case is "Spiralloy."

THIRD MERCURY CAPSULE has been airlifted from McDonnell Aircraft to NASA'S Huntsville center.

LANDING DYNA-SOAR and other advanced vehicles is big Air Force problem. Feasibility studies continue on instrumentation to bring the vehicles in. Eventually, the equipment will be installed in the Recovery Control Center to be established at Edwards Air Force Base.

ADVANCED RYAN Q-2C FIREBEE TARGETS are being ground-launched by four ft. Fruehauf rail-launchers

Production

APACHE solid propellant rocket

motors for low-cost research shots are now in production at Thiokol's Elkton, Md. Div.

LAST REDSTONE has been produced at Rocketdyne.

NEW FLOW-TURN MACHINE at Pratt & Whitney Div. of United Aircraft is now producing large rocket cases. Machine can flow cylindrical shapes with diameters of as much as 80 in., lengths exceeding 20 ft., and 0.015 in. wall thickness.

Procurement

FIRST TWO "AIRTRAC" electronic defense units have been purchased by the Marines. System was developed by Hughes Aircraft's ground systems group to coordinate firings of Terriers or Hawk batteries.

SUPPORT EQUIPMENT "TECHNICAL INFORMATION FILE" will be enlarged this month with 125 additional descriptions of GSE items. "TIF" will then include 875 items. It will eventually include 3000. This catalogue of Air Force equipment (MIL-HDBK-300), is being distributed to about 3640 users by the Air Materiel Command, Wright Patterson AFB.

FIVE FILAMENT-WOUND ROCKET CASES have been purchased by Thiokol-Huntsville. They will be tested as replacement cases for the present steel engine cases on Falcon. The lightweight plastic cases were bought from Brunswick-Balke-Collender.

AIRCRAFT

Design

BOEING 707-120B is now undergoing FAA certification tests at Boeing-Seattle. Plane has fan at front of each JT3D engine, increased wing sweep-back between fuselage and inboard engines. American Airlines and Aantas are converting their existing fleets to advanced configuration.

IMPROVED SKYHAWK will have 27 per cent increase in range over the present A4D-2N. Identified as the A4D-5, new "bantamweight" model will be powered by the lighter Pratt & Whitney J52 jet engine. Douglas will build new model for the Navy.

Development

TURBOFAN VERSION OF J-57 will power the B-52H. The Pratt & Whitney engines are being flight tested in a B-52G at Boeing-Wichita.

AUTOMATIC TERRAIN AVOIDANCE SYSTEM developed by Cornell Aeronautical Laboratory is now being flight-tested in B-57B airplane.

NUCLEAR AIRCRAFT PROGRAM at Convair's Fort Worth plant is now using a 1,500,000-pound concrete "lid" which permits separate measurements of radiation from two reactors operating simultaneously.

A2F-1 INTRUDER will use DIANE inertial bomb-navigation system. Three digital computers used in system have been completed in the last 15 months by Litton Industries.

WING AERODYNAMIC STUDIES conducted by Northrop over ten year period are being considered by Air Force for ultra-long-range missile platform. Two day cruise capability seems possible in such an aircraft. Applications of aerodynamic principles to future transports offers greatly increased range and efficiency.

OLYMPUS 21 turbojet, recently announced by Bristol Siddeley, produces 21,000 lb thrust without reheat. To be installed in Vulcan Mk.2 delta wing bomber, it has intake diam. of 42 inches, basic length of 156 inches.

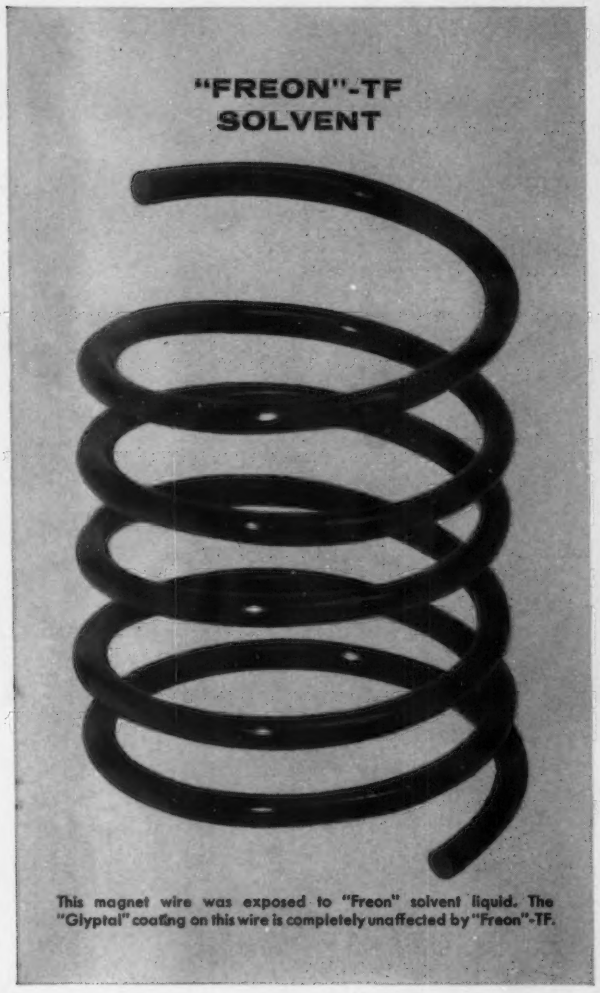
HEAVY PLANE CATAPULT SYSTEM has been accepted by the Navy for installation on the nuclear carrier Enterprise. Catapult designed by Reaction Motors uses air from compression plant built by Carrier Corp.

Production

BELL HELICOPTER CORP will produce undisclosed number of HU-1D helicopters for the Army. Its enlarged fuselage holds 50 per cent more soldiers than firm's HU-1B. Firm says new model could be produced with much available tooling and techniques.

Procurement

$260-MILLION ACQUISITION of 45 jet planes is planned by Trans World Airlines. Purchase would comprise 25 707's and 20 880's plus spare parts and equipment.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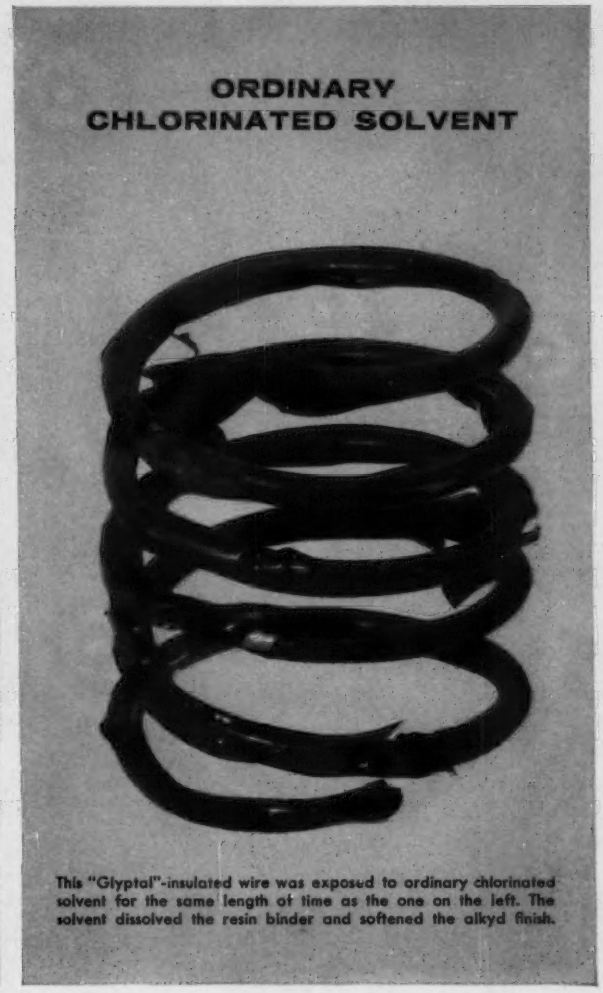
This magnet wire was exposed to "Freon" solvent liquid. The "Glyptal" coating on this wire is completely unaffected by "Freon"-TF.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Mark 3 Meets Missile

Fast technique developed for installing and removing ablation-type re-entry vehicles, with their delicate mechanisms, at ICBM coffins; ground-handling costs pared

By Peter Sigmund

Mark 3 re-entry vehicle, now in hands of SAC troops at several launch emplacements, is flown to Warren Air Force Base, Wyoming from General Electric's Missile and Space Vehicle Dept., Phila. It reaches a Surveillance and Inspection Building at the base in three sections — nose cone, midsection, and flare. Pieces are then checked out and assembled.

Re-entry vehicles are constantly monitored and change of cones must be swift in case of malfunction. When such a swap is necessary, a truck transports two handling and mating carriages in a trailer. One carriage holds a new cone. The other will bring the defective cone back.

Defective cone is first mated to its carriage, which is rolled back on tracks over trailer. New cone is rolled out, raised, and mated. The old cone is then lowered to bottom tracks and taken back to S & I building.

Truck-trailer can reach 50 mph without harming cones. Use of same trailer for new and old cone halved the number of trailers needed in swap sequence. System can also be used with Avco Mark 4 cone.

SAC crews have taken over a similar ground support operation at Vandenberg AFB launch emplacements.

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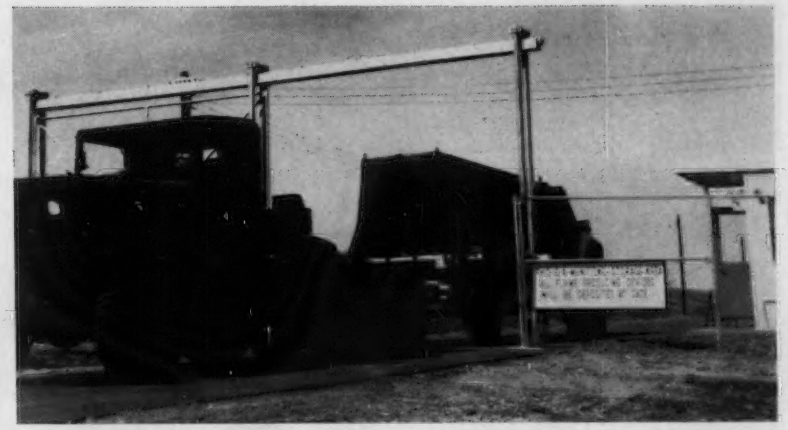
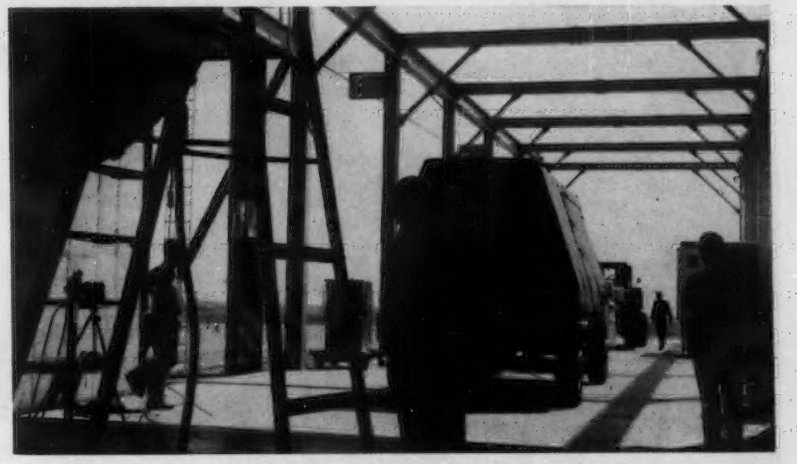


MARK 3 RE-ENTRY VEHICLE leaves Surveillance and Inspection Area at Warren AFB for an Atlas launch emplacement. Standard truck pulls modified Army trailer, which carries Mark 3 in special suspension system. Trailer is made by Bowen & McLaughlin.

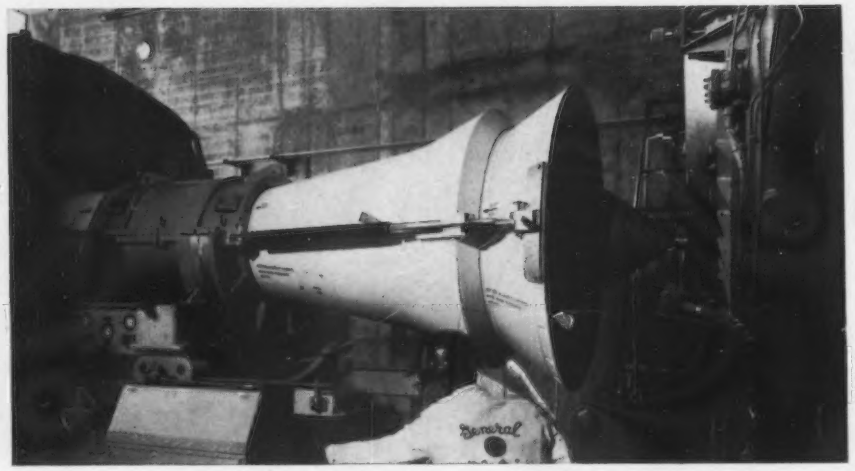


AT COFFIN SITE, TRUCK BACKS TRAILER along line to exaet position about four ft. in front of Atlas. Note open top over front. Missile itself is under roof which slides over front section before firing time.

continued on next page

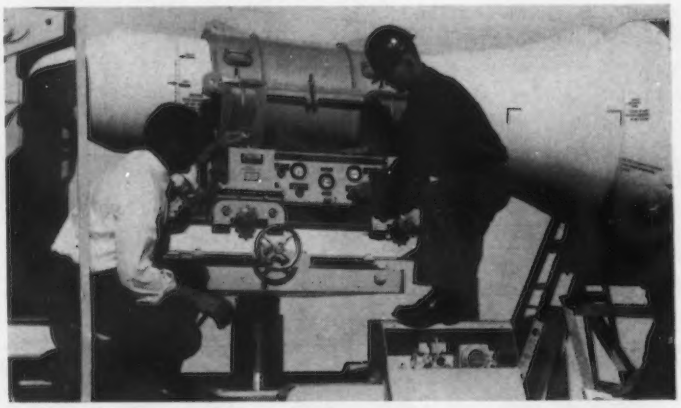
← Circle 47 on Inquiry Card

Mating an Atlas involves extreme care, precise handling procedures



SPECIAL CARRIAGE IS RAIL-MOUNTED on trailer. Mark 3 is first placed in cradle (encircling cone). This unit is lifted onto Handling and Mating Carriage. Ensemble is rolled to rear of trailer before mating operation. Note "spacer" section at rear of cone. This holds explosive bolt, remains with missile after nose cone separates in flight.

HYDRAULIC RAM LIFTS CONE TO ATLAS LEVEL. Centerline is 100 in. from floor. Air bellows in carriage inflate to allow fine positioning with 25 lb. of manual pressure. SAC troops at base use a "mating trainer" to increase skill for operation.



LATERAL POSITIONING IS BEGUN after four rollers are raised under cradle. This allows rolling cone to align bolts. Here re-entry vehicle mechanic eases carriage back towards two alignment pins. Chalmers & Kubeck built carriage to GE specs.

STANDARD BOLTS FASTEN RE-ENTRY CONE to missile. One is shown being torqued. There are 24 bolts in all. New handling procedure saved Air Force an estimated $500,000 in ground support costs.

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How Air Force Maintains Missile Readiness

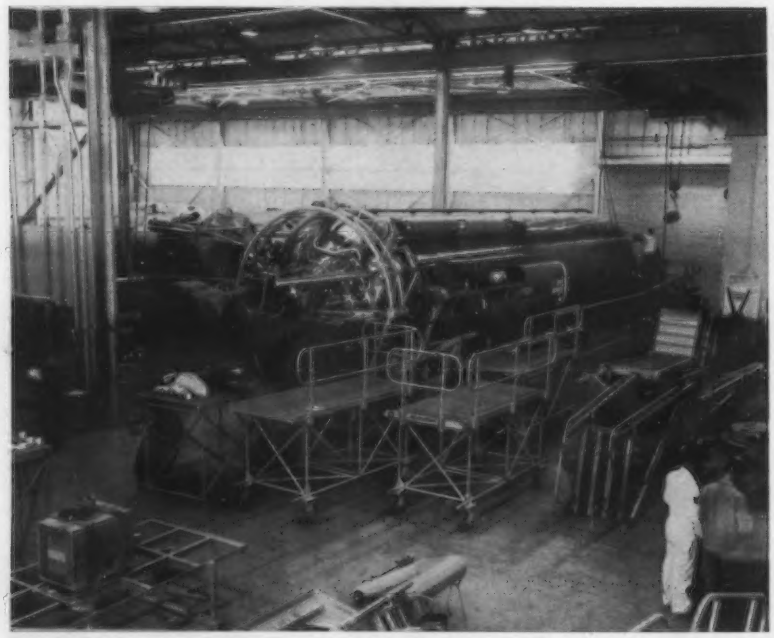
Automatic Programmed Checkout Equipment (APCHE) completely checks Vandenberg Atlases in nine hours during "maintenance" tests

By Philip Geddes

Automatic checkout equipment has taken the guess work out of missile maintenance.

Atlas missiles at Vandenberg AFB are periodically pulled off the pad and back into a Missile Assembly Building for "recycling." At recycle intervals, a bird is plugged into the Automatic Programmed Checkout Equipment (APCHE) for a complete functional check of all systems but the warhead. Installation for check takes about a day. Recycling is usually accomplished within thirty days—the times varies from missile to missile depending on the problems uncovered.

Two complete sets of automatic test systems are installed in the missile assembly building. In addition, every Atlas missile blockhouse contains an APCHE set used to determine daily readiness.



UNDER CONVERSION at Vandenberg Missile Assembly Building Atlas is shown with boosters removed. APCHE system can check in 9 hr what would take 150 hr manually.

Checkout Procedure—The RCA designed, solid state, APCHE serves as the programming core for the test system.

Basic components — punch cards, reading, and print out section are based on a Remington Rand design. These units were reengineered by Autonetics division of North American Aviation with the assistance of Remington Rand.

Prepunched decks of cards are fed into a control console for the system. Each deck of cards represents a system check. The number of cards in a deck varies from 17 up to 519. Fifteen decks are required for a complete missile check. Any particular deck can be started in the console but once a particular sequence is initiated it is necessary to complete the series, in the prearranged order, to obtain the correct follow-on of events in the missile. The console operator can stop, start or override the checkout operation at will.

As each card starts an interrogation signal to the missile system under check, lights on the console panel show the status of the component or system being scrutinized. At the same time, a readout tape in front of the operator prints the card number, the actual test value obtained along with the upper and lower limits. Should a value be out of limits, the printed readout ap-

pears in red instead of black and the checkout stops. The missile system analyst running the console compares the value received with the operating manual description of each check sequence. He can then elect to override the system and continue the test or delay further testing until the defect has been corrected. Communication is provided between the console and critical members of the eleven-man Air Force checkout crew.

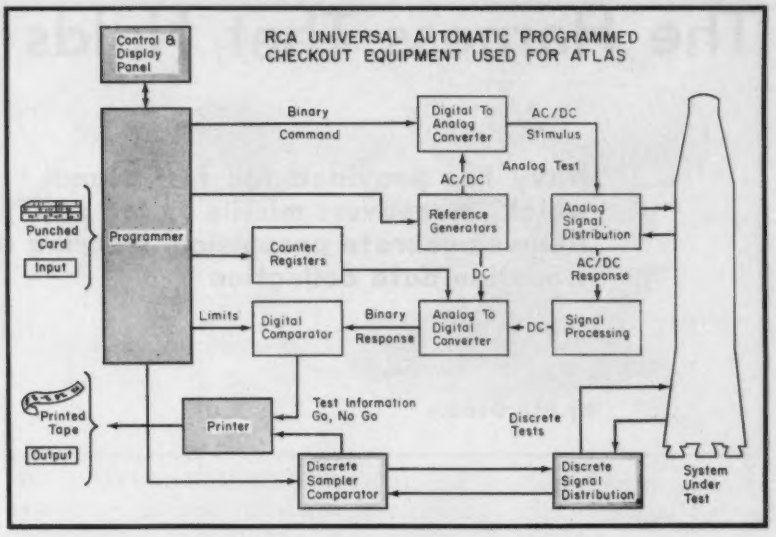
Systems Checked—Each of the system checks listed below represents one set of cards being fed into the control console. Many of these are self checks, i.e., the test system checking itself.

(1) Self test of APCHE before checking missile system. (2) External hydraulic power equipment —self test prior to application to missile. (3) Hydraulic fill and bleed test—on missile.

(4) External pneumatic power equipment—self test prior to application to missile. (5) Auxiliary ground support propulsion test—on missile.

(6) Airborne power supply—external self test. (7) Auxiliary power supply and ground power control—external self test. (8) Propulsion system leak test—on missile. (9) Pneumatic (static) system test—on missile. (10) Autopilot ground control and target data unit—external self test. (11) Autopilot system test —on missile. (12) Autopilot guidance system test—on missile. (13) Propulsion system test—on missile. (14) Pneumatic system test — on missile. (15) Propellant utilization test—on missile.

Main Components — APCHE Atlas checkout equipment in the missile assembly building at Vandenburg directs semi-automatic test equipments from General Electric and Rocketdyne. The GE part of the system is related to checking out the missile guidance system and the Rocketdyne to propulsion. Hydraulic power for tests is delivered from a Sprague Engineering hydraulic power supply unit delivering from 2000 to 3000 psig. Pneumatic testing is divided into two



WHAT APCHE DOES

GENERATES

VOLTAGE
dc or peak ac
10mv to 10v in 10 mv steps, 50mv to 40v in 50 mv steps, and 50v

modulated ac
400cps, mod. 0.5 to 20cps

PRESSURE
zero to 18 psig in 12 steps

DISCRETE SIGNALS
over 100 simultaneously

CONTROLS
Missile functions and ground support equipment

SELF CHECKS
For increased reliability

MEASURES

VOLTAGE
ac or dc to 500v

RESISTANCE
to 1.0 meg

FREQUENCY
twenty to 40,000cps

PHASE SHIFT

A FUNCTION AFTER A TIME DELAY
50μ sec. to more than 77 hours

A FUNCTION at t_1, t_2, . . . t_n

OPERATING TIME of RELAYS, ETC.

SERVO SYSTEM
in-phase and quadrature components

PRESENCE or ABSENCE of DISCRETE SIGNALS
over 100 simultaneously

COMPUTES

Adds
Subtracts
Stores

RECORDS

Actual test values
upper and lower limits
and no-go circuit locations

groups, dynamic and static: power for each pneumatic group coming from separate CEC, Systems Division units.

The dynamic pneumatic checkout unit supplies nitrogen and helium to simulate in-flight conditions on systems in the missile. The static pneumatic checkout unit is used for testing lines to the missile normally connected on the pad before flight; again nitrogen and helium are used for tests. Both gases feed into the checkout units from a gas farm located outside the missile assembly building. As fuel burns off during a missile flight, the ratios of liquid propellant and oxidizer to gas space in the tanks are constantly changing. Simulation of this function, critical to the propellant systems, is achieved by an ullage unit, completely separated from the pneumatic units. Nitrogen pressure on the propellant tank during test is approximately 12 psig and 6 psig on the oxidizer tank.

System Problems — Air Force operating personnel say that troubles in the Atlas APCHE have been of "routine nature confined to calibration and normal maintenance." The seond checkout system installed in the missile assembly building is a refined version of the first. The first being designed for the vertical pad installations and the second for the horizontal missile installations in coffin pads.

✦

The Harness That Holds Polaris

Navy has provided for test stand which "maneuvers missile on the pad"; Allows accurate propulsion, steering and vibration data collection

by Phil Geddes

Navy has provided for a comprehensive set of design tools to expedite the Polaris project. Simulating the flight of the missile on the ground with the solid rocket motor blasting is one of them.

Captive test firings offer the only practical opportunity to subject the integrated missile structure and systems to the actual major force functions encountered in flight. It is especially desirable in captive firings to provide limited freedom for the missile to respond to vibrational excitation and flight control operation representative of typical flight maneuvers. In this way the dynamic operations of the interrelated guidance, flight controls and propulsions systems can be determined and studied under situations similar to those expected in flight.

The degree of flight simulation you can get depends on how much is spent on the test facility, since there are obvious limits to the amount, a reasonable balance between facility complexity and sophistication of test objectives must be struck.

Lockheed Space and Missile

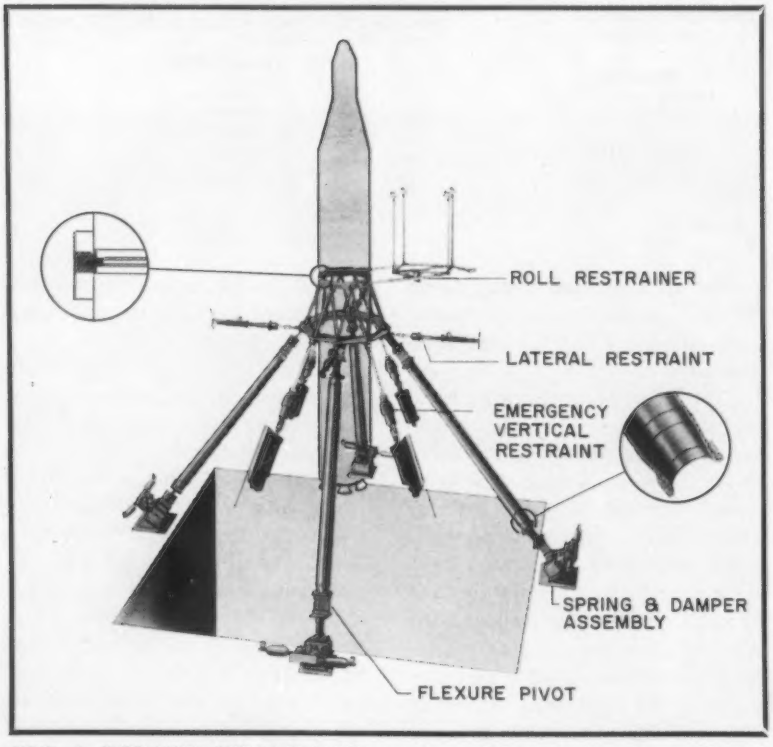
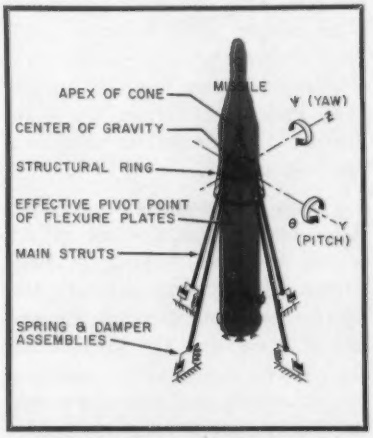


FIG. 1. POLARIS TEST STAND consists of four-strut system with universal joints to allow "maneuvering on the pad." System also allows more accurate collection of vibration data.



FREEDOM OF MOVEMENT in pitch, roll, yaw is possible in Lockheed designed "soft stand." Aerojet's Actron Div. and Barry Controls are subs.

Division developed the design concept for ground testing Polaris. From the inception of the project, the dynamics of the stand to be built were paramount, rather than the normal parameters of strength, rigidity and weight of the test stand. The resulting system is unusual in test stands.

Restraint System—These design criteria governed development of the "soft stand":

(1) Test stand restraint system must exert predictable and controllable influence in response to shock and vibration acceleration forces imposed by the propulsion system.

(2) Restraint system must allow rotation in pitch and yaw in response to control system forces. (Frequently in missile design, the details of forcing functions and responses characteristics of integrated structures are unpredictable. Unexpected magnitude of resonant response of undamped "rigid mounts" has occasionally been disastrous.)

(3) Dynamic influence of restraint system must be determined and controlled to avoid accidental damage from acceleration forces.

(4) Reduction of dynamic mass and center of gravity shift due to fuel burnoff must be accounted for. These factors in the changing dynamic nature of the missile, combined with structural limitations make it necessary to change damping and/or restraint stiffness during a firing.

(5) Safe environment. Reliable system.

(6) Other considerations: Adaptability to a variety of tests; stops for limiting lateral and angular displacement; emergency controls for rigidly holding missile in place; potential useability without attention for 24 hr after initial adjustment; predictable changes in system with age and use; low sensitivity to rocket test environment.

Dynamic Restraint System—After studying many different concepts, Lockheed evolved the design used in the Santa Cruz facility "soft stand," and made the necessary dynamic analyses. Aerojet General Actron Division did the detail design of the dynamic restraints with Barry Controls Inc., who were subcontractors to Aerojet for design and analysis for certain portions of the system.

The stand consists of a four strut system, as shown in Fig. 1, built inside a conventional looking test stand. The inner frame transfer loads from the missile structure to the restraint system proper. Suspension of the inner frame consists of four light weight struts with flexure pivots provided as universal joints at each end of the struts. These pivots are of the type commonly used in wind tunnel balances. The lower end of each strut attaches to

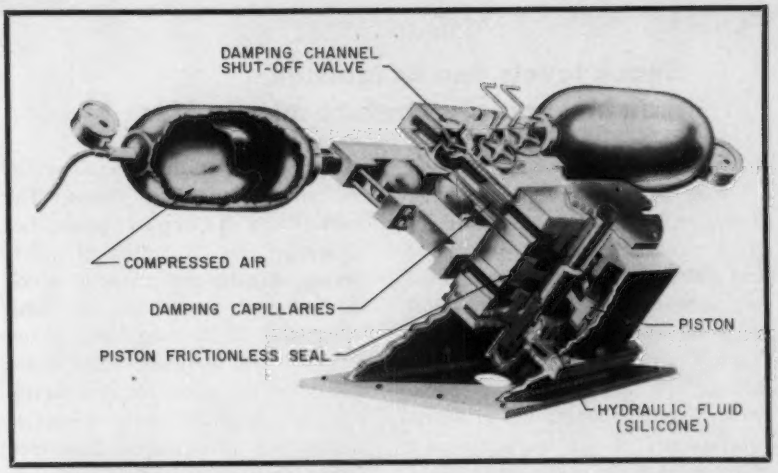


FIG. 2. HYDRAULIC CYLINDER attached to Polaris test stand allows translational freedom. Displaced hydraulic fluid and compressed air give elastic damped restraint.

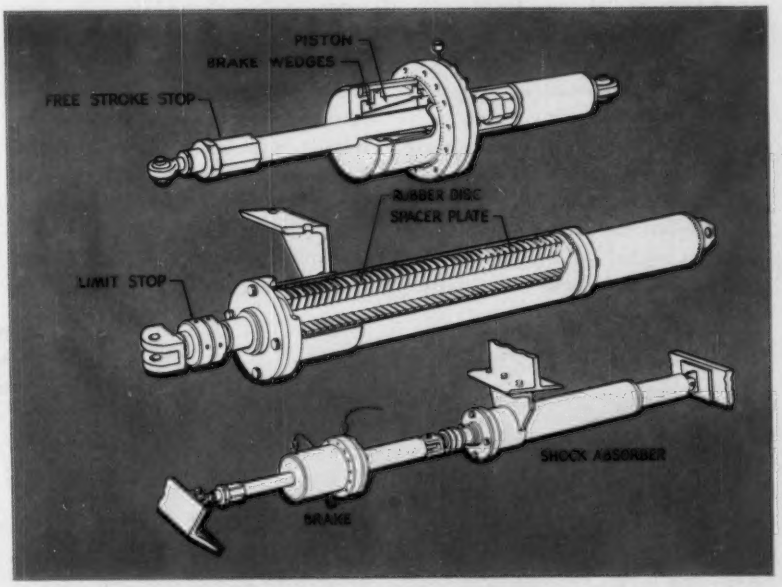


FIG. 3. SECONDARY RESTRAINTS to Polaris movement when it is fired in test stand are provided by units like these. They have a "primary" function, and also serve as backup devices. Lateral restraints require heavier structures than vertical restraints.

Shock levels due to ignition can be evaluated before missile flies

a spring and damper cell.

Roll Stabilization of the inner frame is provided by a parallelogram strut arrangement suspended and articulated to provide rotational but no translational restraint. Limit stops attached between the inner frame and the outer test stand structure provide a safety feature in the event of missile instability or structural failure of the main dynamic restraint system. The system is adapted for first or second stage firings by changing the mounting element.

Rotation in pitch and yaw is possible about a virtual center which is the apex of the cone made up by the support struts. Angular freedom is limited by the strut geometry, flexure deflection limits and physical limit stops. A practical design limit for angular freedom was considered to be plus or minus five degrees from the vertical axis.

Translational freedom is primarily provided by the spring and damper assembly and to a lesser extent by the elastic compliance of the struts and inner frame. The spring and damper assemblies shown in Fig. 2 consist of a hydraulic cylinder and piston to which the support struts are attached. Movement of the large area piston displaces the hydraulic fluid above and below the piston through damping tubing to and from the respective compressed air chambers, thus providing an elastic damped restraint.

Secondary Restraints — Other systems are required to provide limit stops in both translation and rotation and as a safety measure in the event of primary restraint failure as mentioned earlier. Since the four strut system constitutes an unstable support with compression loads in the struts, the secondary restraints also may be used to constrain the missile in an upright position before firing. In addition to emergency control, the secondary lateral restraints (Fig. 3) are designed to provide a terminal compliance to pitch or yaw displacements in such a manner that excessive angular accelerations will not be sustained when displacement is stopped plus or minus five degrees from vertical. The lateral restraints are similar in mechanical principle to the vertical restraints, although the latter are naturally much larger. Adjustable limit switches are used to automatically clamp the brake shaft of the restrainers when unsafe excursions are encountered.

Usefulness of System—Test experience with the "soft stand" technique has shown that the method is a good one to verify the functional operation and design of electrical equipment and hardware under conditions that closely approximate in-flight environment sans aerodynamics. While close correlation of captive-test, high-frequency vibrations with flight valves has not been possible in microscopic detail, Polaris experience has shown that the missile structural bending modes can be detected and evaluated as to their effects on important subsystems like flight controls. Shock levels due to ignition has provided, before actual flight tests, firm knowledge of what could be expected in flight. In addition, these tests provided an early opportunity to determine performance of telemetry measurements subject to motor firing conditions where telemeter pack measurements subject to motor firin ing conditions where telemeter packages were subjected to electrical noise, heat, and vibrations.

The soft-stand technique has also been useful to ascertain the effect upon missile subsystems of the acoustic excitation through the missile skin from motor exhaust.

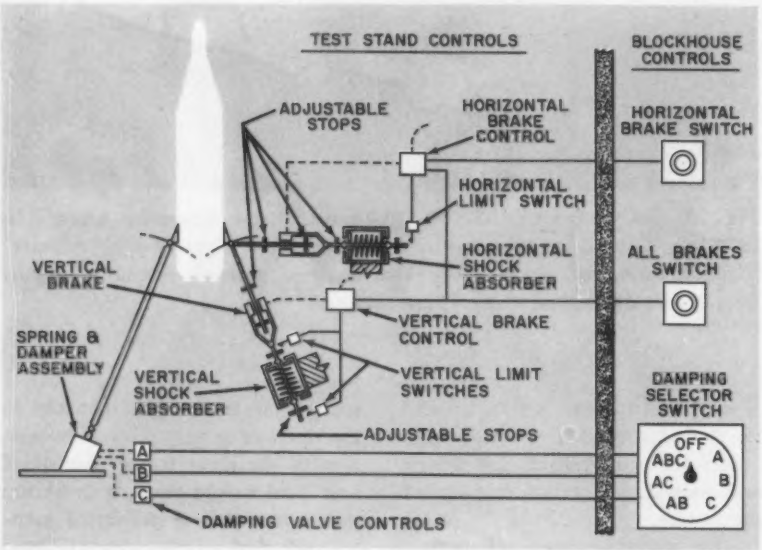


FIG. 4. CONTROL SYSTEM for Polaris stand shows remote devices in blockhouse where TV and instrument display are used to monitor action of restraint system.

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This article is based upon a paper "Systems Testing on Dynamic Restraints at Lockheed SCTB," by A. L. Hubbard.

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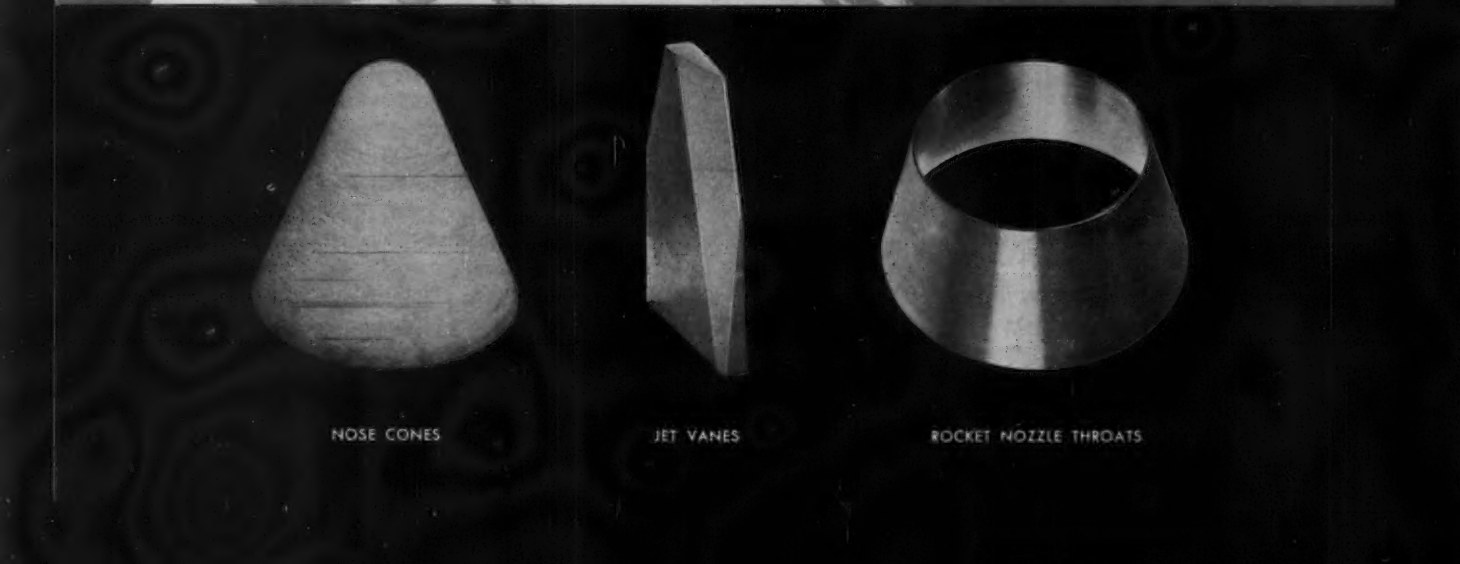


NOSE CONES

JET VANES

ROCKET NOZZLE THROATS

Telemetry's Tasks In Titan Tests

Two things control value of missile test: (1) Accurate data collection, (2) Accurate data analysis; This is how Martin gets propulsion data on Titan

By S. Lukens, and W. M. Van Beek, Martin-Denver

The value of a missile flight test hinges greatly on two things: Accurate collection, and accurate analysis of propulsion data. The collection phase is particularly critical because it is compacted into a fraction of a missile's flight time.

Problem areas start with instruments which convert measurements of physical variables into electrical output. Transducer commonly used for this conversion include: strain gages, potentiometers, thermocouples, thermistors, etc.

Criteria For Reliability—Complete failure of a transducer or other component is not the only criterion in determining its reliability. The component may be affected by a change in environment to the extent that the data it transmits is useless. It is extremely difficult in an airborne system, where weight and size are important, to design a component that is not affected by its environment. An initial step involves qualifying components to the environment anticipated in flight. Additional precautions are taken during installation to place all items in locations where the environment varies least. However, transducers and other electronic equipment must be located in engine compartments; this requires that vibration isolators be used. Also needed are radiant and convective isolation for strain gage transducers, which, although temperature compensated, will vary drastically if one leg of the bridge is heated before the others.

Transducers For Titan—For the Titan, the most accurate transducers available are selected on the basis of laboratory and environmental comparison. Although some transducers are more accurate than those presently used, they cannot be considered for flight because of weight. Some transducers, although smaller in size and just as reliable in laboratory functional tests, prove inadequate under actual environmental conditions.

Where feasible, transducer output at ambient is some value other than zero volts. This gives one point (off-zero) that can be verified; this provides greater confidence in the data. When the ambient varies from what it should be, this one point provides the basis for correcting the data. On voltage signals where the output is zero or full scale, a bias voltage is placed so that the particular channel may be verified (as to whether it is working or not) with a zero signal output.

Usually, transducers are used which do not require signal conditioners. However, many measurements require signal conditioning. At present, all of the signal conditioners are adjustable, allowing flexibility in that a variety of transducers with different outputs may be utilized. Initially some of the conditioners were unstable, but redesign has resulted in stability over a long period.

Signal conditioning capabilities are as follows:

- Amplification, bias, and null for millivolt signals converted to 0 to 5 volt signal.
- Frequency converted to 0 to 5 volt signal.
- AC voltage signals converted to 0 to 5 volt signal.

Titan Telemetry — Telemetry system used for the Titan is of the Pulse Duration Modulation/Frequency Modulation (PDM/FM/FM) type. Three to four packages are used, each with a capability of

SHOCK MOUNTS must be provided for certain data collection devices. Vibration amplifier chassis is shown. Barry is manufacturer.

HEAT REFLECTIVE TAPE is used in Titan tests to protect wiring and pressure transducers from rocket environment.

14 continuous channels or 13 continuous channels and one commutated channel (86 measurements capability, commutated 10 times per second). All signal inputs to the package must be 0 to 5 volts. On the early missiles, telemetry packages with adjustable subcarrier oscillators were used, but now an all-transistor subcarrier is used which neither allows nor requires adjustment. No telemetry packages have failed during a flight test despite heavy usage during Air Force acceptance testing, system setups and in firings prior to flight.

To eliminate complexity, calibration is inserted at the input of the telemetry system. Calibration consists of 0.0 to 5.0 V signals in increments of 0.5 V prior to launch. During flight, calibration is made about every 75 sec with a 2.5 V and 5.0 V signal. This calibration occurs only on the continuous channels. Commutated channels are calibrated using 2 channels, one for zero volts and the other for five volts. This permits compensation for all channels which have 5-volt excitation, if the 5-volt power supply should vary. The 10-volt power-supplies are used for strain gage measurements; outputs are also recorded on the commutated channels, so if a shift occurs, compensation may be made.

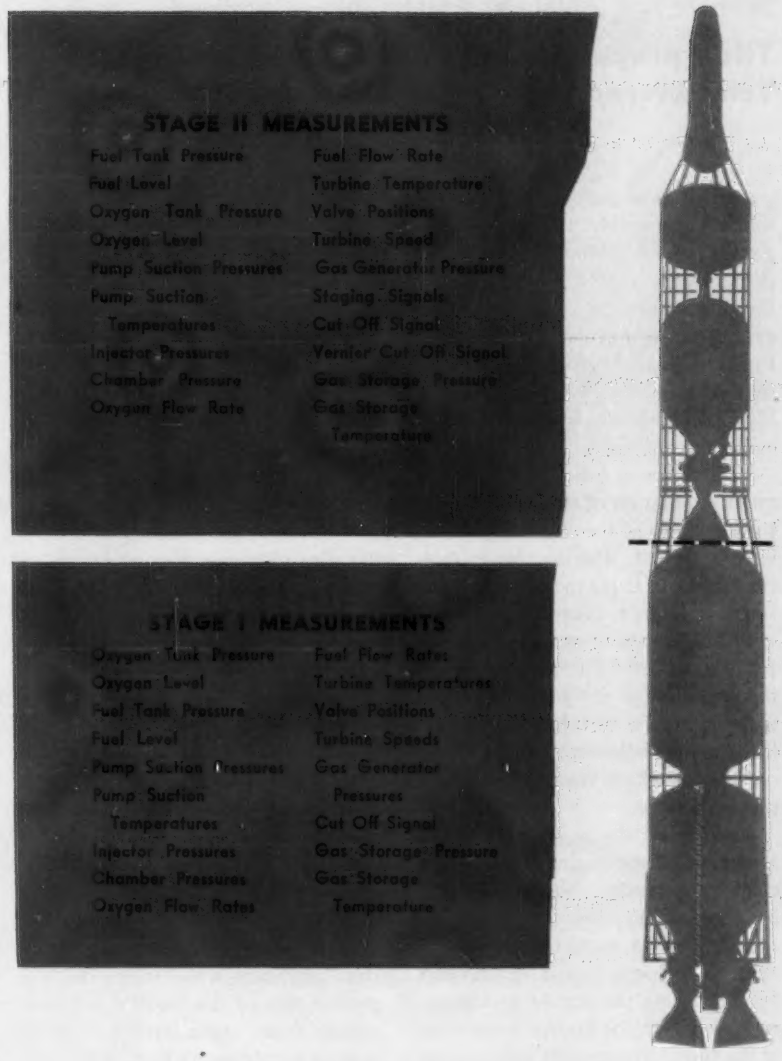
Insuring Accuracy — To collect accurate data, proper handling and calibration of the equipment must be insured. This involves two areas: (1) Incoming inspection and calibration, and (2) the test stands. Control is exercised by the instrumentation design group in writing the specifications for the testing in these areas and also providing assistance as problems arise.

Incoming inspection calibration consists of an 11-point stimulus of the pressure and temperature probes. This calibration is accurate to 0.1 per cent of full scale for pressure transducers and ± 2°F for temperature probes between —100°F and 200°F. Vibration probes are calibrated by the vendors. Venturi flowmeters are calibrated by air, and converted to the gas used. The turbine flowmeters for the Titan are installed by the Aerojet General Corp. The original flowmeters were bench calibrated and then a correction factor was made during firing. This was because the flowmeter was located so close to the pump that the pump affected calibration. Recently Aerojet has incorporated a new flowmeter with higher-pitched vanes which requires only bench calibration.

On the test stand, preparatory to preflight and prefiring, all functions which are adjustable are checked to verify whether they require adjustment. This consists of the following steps:

- Adjusting the power supplies with full load applied. Since they provide power for potentiometers, strain gages and signal conditioners, they directly affect accuracy and are adjusted to ± 0.1 per cent.
- Adjusting the signal conditioners to give proper outputs within ± 1 per cent at end limits of measurement. End limits of the measurement simulated, as well as several intermediate points, and the input to the telemetry package are recorded as calibration data.
- Reading of all ambients and using them to verify the output of all measurements.

Acquired data is recorded on magnetic tape and must be played back to be usable. Flexibility of



Titan propulsion uses "calibrated engine," Telemetered data is checked against a "standard"

ground-station playback equipment makes it possible to utilize flight data in many different ways. For performance analysis data is played back at a slow paper-speed so that system noise may be averaged out. For analysis of propulsion system malfunctions data is played back at high paper-speeds for exact determination of the failure sequence.

Immediately following a flight, a quick evaluation of the data is made to determine if the flight objectives were achieved. During this evaluation the data is played back without signal reference compensation and with only rough corrections applied for transducer drift. The results of this evaluation are published in a formal report to the Air Force fifteen days following a flight. Recommented action items result from this evaluation.

Following the quick evaluation, a detailed examination of each data channel is made. All system calibrations are applied and necessary corrections are made for transducer drift. The correction is determined by comparing the pretest and burnout value with the known conditions at the time. That a drift was present can usually be determined quite easily. To determine when a drift started is more difficult and can only be determined by comparison of other associated data-channels.

Performance Parameters — The following performance parameters are of utmost importance: burning time, propellant mass-flow rates, propellant mixture-ratio, thrust, specific impulse, buildup and shutdown impulse, pressurization - gas usage and propellant outage. Each of these parameters is corrected to a standard inlet condition (pump to propellant) for both the booster and second stage engines. The corrections for inlet conditions are computed with the aid of an IBM 704 computer.

Prior to each launch the predicted engine performance is analyzed to determine the propellant loads required to make the range objectives. Missile range is very sensitive to engine inflight mixture ratio, specific impulse and remaining propellant after shutdown (outage). It is therefore imperative to compare actual flight performance with the predicted in order to make improvements in propellant loading techniques.

Buildup and shutdown characteristics of engine play an important part in alignment of thrust vector during launch, to effect a successful staging of the missile, and to trim the second stage shutdown impulse by vernier thrust for meeting range objectives.

Titan propulsion system uses a "calibrated engine" concept rather than a "propellant utilization" system to minimize propellant outage. This requires accurate calibration of instrumentation used for static firings. To analyze flight performance, consideration is given to telemetered data accuracy which does not approach that of the landline data obtained from static firings. Therefore, a continuous effort is directed to statistical studies of the flight data and to the comparison of static firings and predicted flight performance obtained by an IBM program.

Problems of Automation—Automatic data reduction techniques have not as yet been employed to any great extent. Reason for this is that any automatic readout device samples the data at discreet times and may distort the data by detection of noise on individual channels. Also, smoothing techniques degrade the data, especially in transient areas. The actual data trace from a tape playback is reproduced for reporting purposes by a photographic method so that no information is lost in manual curve-plotting. Related data-traces are grouped together on a single paper record for convenience in analyzing each subsystem.

To determine sequence of events, a correction is made for the time lag of the lower frequency channels so that all channels may be analyzed on a similar time basis. Consideration is given to the frequency response of each continuous data channel as well as to the commutated channels. Frequency analysis of commutated data is inadvisable because of the low frequency-response of a data channel sampled only ten times a second. However, commutated sampling of an actual high-frequency cycling will result in an unintelligible band of noise centered about the average level of the data trace. Therefore, rapid transient analysis should be confined to continuous data only.

Role of Optics — In the final analysis, internal data must be compared to external tracking data. External data is acquired at lift off by a CZR fixed camera. Multiple exposures are obtained during the first 100 ft of vertical rise of the missile. Position and velocity are reduced from these data which are fed into the IBM 704 computer to obtain lift-off thrust and specific impulse.

Additional tracking equipment used during later phases of powered flight include: Askania photo theodolite, Azusa transponder, and FPS-16 and Mod. II radar skin tracker. Propulsion system data obtained by external means is then compared to performance figures obtained from internal data.

Changes are being considered in Titan data acquisition and utilization to further increase its reliability.

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of this article can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES, Chestnut & 56th Sts., Phila. 39, Pa.

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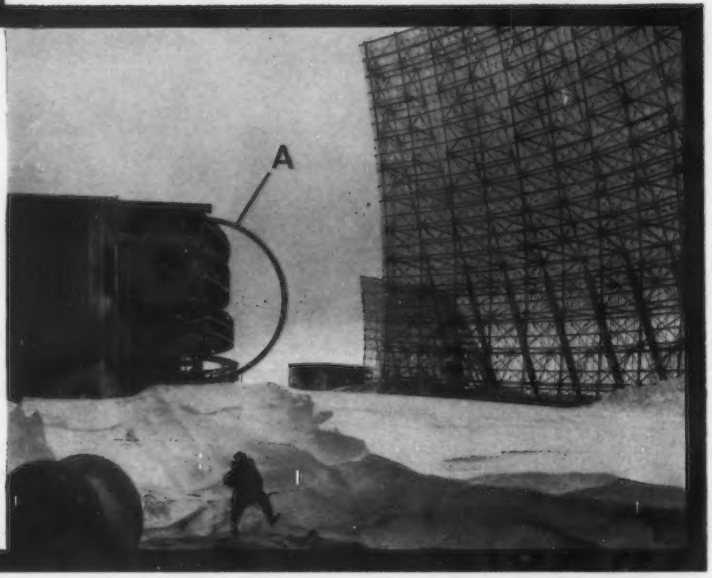

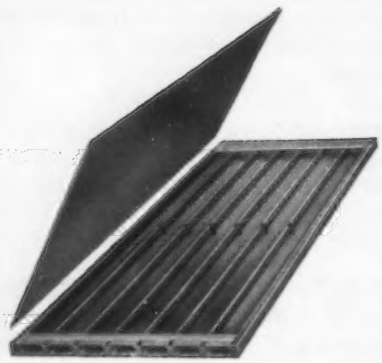

Radar Window of G-E TEXTOLITE 11546 protects exposed feedhorns (A) while permitting transmission of radio frequency energy. Hot air continually blown through window cells prevents ice formation during sub-zero arctic weather.

Towering high over the Arctic wasteland, giant radar antennas like this one (each larger than a football field) form part of the surveillance radars for the U. S. Air Force's Ballistic Missile Early Warning System (BMEWS). Developed by G-E's Heavy Military Electronics Department for RCA, BMEWS prime contractor, these surveillance radars will be instrumental in providing approximately a fifteen minute warning in case of a missile attack across the northern polar region. The first of three BMEWS sites is nearing completion near Thule, Greenland.

So gigantic is this surveillance radar that feedhorns and other vital equipments are housed in separate scanner buildings. Protecting each feedhorn from the sub-zero arctic weather is a Deicer Panel Assembly or "radar window" fabricated from G-E TEXTOLITE 11546, a G-10, high IR, glass epoxy laminate.

Micarta Fabricators Inc., an independent Chicago fabricator, built the windows for the Andrew Corporation who had the overall responsibility for the feedhorn-window system. Andrew specified TEXTOLITE after conducting a development program to select the most suitable material consistent with low cost. Tests prove TEXTOLITE 11546 meets the rigorous electrical, mechanical and environmental (—70° to +50°F, temperature variations, winds up to 185 MPH) conditions inherent in the BMEWS project.

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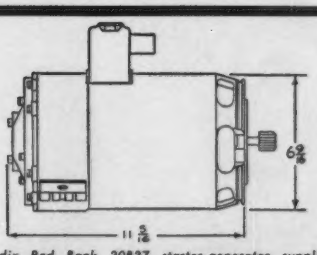
BENDIX STARTER-GENERATOR PROVIDES "KICK" AND POWER FOR U. S. ARMY'S NEW "MOHAWK"

One of the largest aircraft ever to enter Army service, the Grumman AO-1 "Mohawk" has all-weather, day or night observation capabilities.

The "Mohawk's" electrical system includes two Bendix starter-generators and regulators. During engine starting, the units operate as high torque electric motors, with power supplied externally. As the engine ignites, the units automatically shift from starter to generator function.

These Bendix starter-generators are rated at 30V., 400 amps, with a speed range of 4,000-8,000 RPM, and meet MIL-G-6162. They are available with a variety of air spouts and have accommodations for QAD mounting.

This versatile package, combining starting and power generating functions, is another example of Bendix ability in delivering power requirements. Get further details from RED BANK GENERAL PRODUCTS DEPARTMENT.



Bendix Red Bank 30837 starter-generator supplies 65 lb. ft. of starting torque at 1400 RPM. It is dependable, compact, and weighs only 53 lbs.

GENERAL PRODUCTS DEPARTMENT

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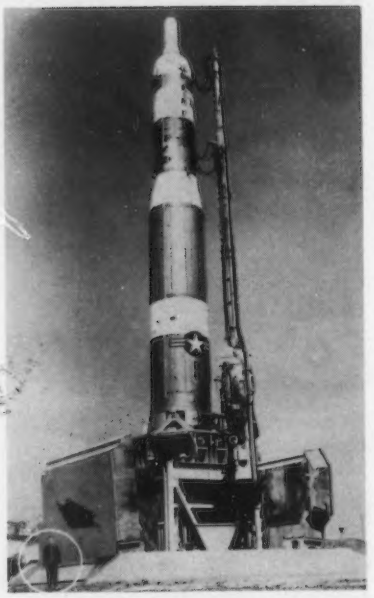
Air Force Digs In

Underground launching bases being readied for Titan, Atlas, Minuteman: GSE and personnel training are 80% of system cost

By Col. W. D. Alexander, USAF
Asst. Deputy Commander for Facilities
Headquarters BMD



TITAN EMERGING from silo replete with servicing boom. American Machine & Foundry Co. launcher has gear to ignite engines.

MINUTEMAN DESCENDING into silo for test firings at Edwards. Silo is simple "hole in ground." First base is at Great Falls, Mont.

Ballistic missiles, like airplanes, need takeoff points. Fashioning a base of operations for a modern missile is a complex and demanding job.

A salient fact, little realized, is that four-fifths of a ballistic missile weapon system is, like an iceberg, not readily apparent. Fully 80 per cent of the total system, and almost 80 per cent of the cost, is vested in ground-bound equipment and personnel. It is quite apparent then, that all of the hardware bred from talents and technologies in the aerospace industries does not get airborne.

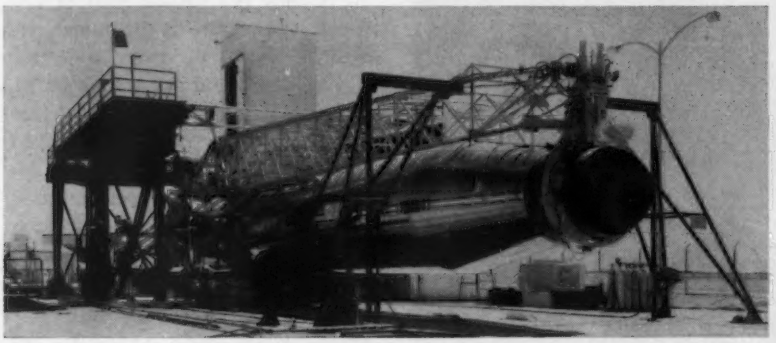
The concurrency concept has played a major role in the construction of fixed launching sites by Air Force (AF). That is why "soft" "semihard," and "hard" sites are under construction simultaneously.

By taking the calculated risk—assuming that new weapons will conform to design theory—early operational deployment is being made practical. Bases should be ready as missiles become available.

Planning and Spending—By June 30, 1959, AF had placed under contract for construction nearly $900 million to support the production, test, training, and operational phases of the ballistic missile program. Of this amount, approximately $115 million has been contributed by the missile contractors for expansion of production facilities as an expression of their confidence in the program. About $230 million represents the Air Force investment in production equipment and test facilities; and $550 million of military construction funds have gone into test, training, and operational bases.

The Air Force share of the fiscal year 1960 Defense Department construction budget is $776 million. Of this total, approximately two-thirds will be spent for the construction of ballistic missile and space system bases.

ATLAS RECLINING in erector-launcher to be used at soft and semi-hard sites. Concrete bunkers will afford some bomb blast protection.



At the outset, it was recognized that the installations aspects of AF ballistic missile programs could not be accomplished under the normal administrative organization and procedures within the allowable time span. In order to tie the designer of the facilities as closely as possible to the developer of the missile, it was decided that AF should directly manage the design work. In fact they were made responsible through the Air Force Ballistic Missile Division for accomplishing the initial operational capability of ballistic missile weapon systems.

Various firms have been awarded contracts for architect and engineering services. Most of the actual construction work is, however, being supervised by the Army Corps of Engineers.

When the ballistic missile development program began in 1954 there were two companies engaged in preliminary hardware work. Since then, the expansive ballistic missile programs have grown to embrace 25 associate contractors, more than 200 sub-contractors, and thousands of suppliers. A vast government-science-industry team makes it the biggest development program in military history.

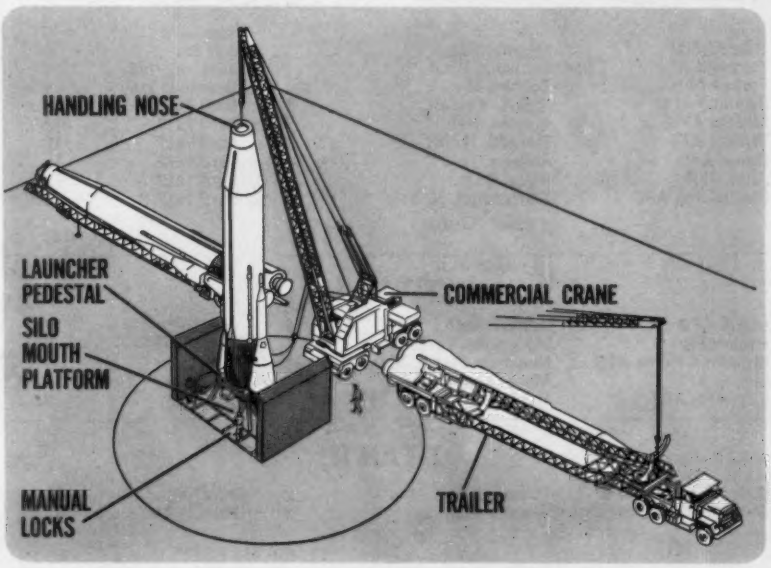
Out of this program is emerging the "new look" of our nation's total defense structure, as missile bases begin to take shape across the country. Programmed for are 13 Atlas and 14 Titan squadrons. Work is in varying stages of progress toward the early completion of these facilities.

The site for the first three Minuteman squadrons will be near Great Falls, Montana. Construction awards will be made in January 1961.

Atlas—How Many Where—At Cheyenne, where the first Atlases will become operational in number, launch sites are above ground. The missile will be stored and maintained in the horizontal position. This installation has been referred to as a "coffin." An hydraulically actuated erector will place the missile in the vertical position for firing.

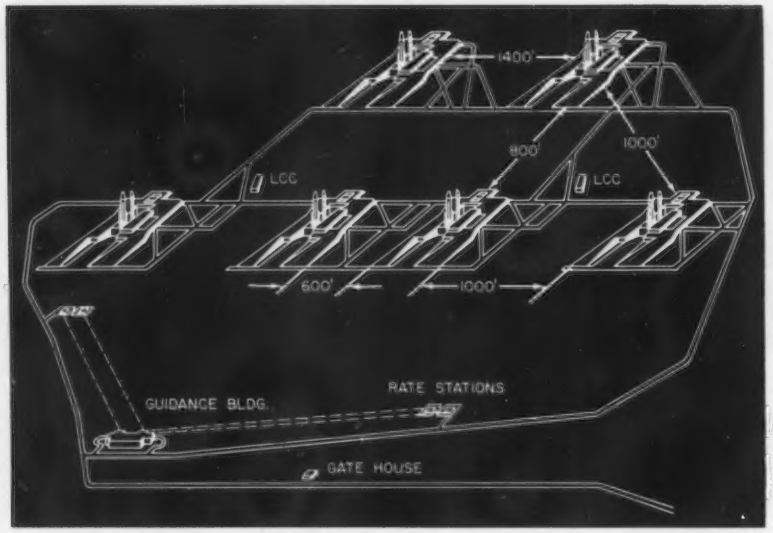
The second round of Atlas bases (Fairchild AFB, Forbes AFB, and Warren III) will be protected by dispersal and a degree of hardening. The bunkers, or coffins, will be made of reinforced concrete to withstand minor nuclear blasts.

The word, "hard" as a measure of protection of missile launch sites from enemy attack, is of course relative. The scale of hardness might conceivably run from "soft" for which no protection is provided to "superhard" which would indicate immediate launch capability after a direct hit by the largest feasible nuclear bomb. Somewhere between these two extremes is a condition called "hard." This value is based on estimates of enemy missile potential, accuracy of bomb



ATLAS SILOS will be built first at Schilling AFB, Kansas. Missiles will be lowered into 170-ft deep shelters, raised by elevator. These "hard" squadrons will have 12 missiles each; 6 squadrons are planned.

Switch to inertial guidance in ICBM's will eliminate antennas, decrease vulnerability



THREE BY TWO LAYOUT will be used for Cheyenne W-1, squadron. Atlases will be stored horizontally in bunkers, elevated for firing.

ATLAS

BASE	LOCATION	No. SQDS.	CONF.	TOTAL MISSILES
Vandenberg AFB	Santa Maria, Calif.	1	soft	—
F. E. Warren AFB	Cheyenne, Wyo.	3	soft 3x2	6
			soft 3x3	9
			semihard	9
Offutt AFB	Omaha, Neb.	1	soft 3x3	9
Fairchild AFB	Spokane, Wash.	1	semihard 1x9	9
Forbes AFB	Topeka, Kan.	1	semihard 1x9	9
Schilling AFB	Salina, Kan.	1	hard 1x12	12
Lincoln AFB	Lincoln, Neb.	1	hard 1x12	12
Walker AFB	Roswell, N. M.	1	hard 1x12	12
Dyess AFB	Abilene, Tex.	1	hard 1x12	12
Altus AFB	Altus, Okla.	1	hard 1x12	12
Plattsburgh AFB	Plattsburgh, N. Y.	1	hard 1x12	12
				123

TITAN I

Lowry AFB	Denver, Colo.	2	hard 3x3	18
Beale AFB	Marysville, Calif.	1	hard 3x3	9
Mountain Home AFB	Mountain Home, Idaho	1	hard 3x3	9
Larson AFB	Moses Lake, Wash.	1	hard 3x3	9
Ellsworth AFB	Rapid City, S. D.	1	hard 3x3	9

TITAN II

Davis-Monthan AFB	Tucson, Ariz.	2	hard 1x9	18
McConnell AFB	Wichita, Kan.	2	hard 1x9	18
				90

MINUTEMAN

Malmstrom AFB	Great Falls, Mont.	3	hard	150

delivery, size and number of bombs, number and dispersion of our launch complexes, cost of launch construction, degree of launch automation and hundreds of other items.

Hardness is usually expressed in pounds per square inch of airblast overpressure at the launch site and the energy yield of the nuclear devices in kilotons or megatons. Thus, assuming there is a surface burst of a weapon of prescribed yield, the air blast pressures will decrease with distance from the burst to the design overpressure for the base. The implication is therefore that a base inside the circle of higher overpressures will fail and those outside will be safe. Obviously, no such demarcation exists for there will always be uncertainties in both the environment and the abilities of the base to withstand the environment.

The concept of hardening will be carried to an advanced degree with the squadron to be built at Schilling AFB, Kansas, and in all subsequent Atlas units. There, the missiles will be inserted into underground silos for full protection against anything short of a close hit by a nuclear warhead. Sheltered in these 170-ft deep silos, the missiles can be fueled below ground and raised by elevator to the surface for immediate launch.

Early squadrons will have widely varying numbers of missiles. The Vandenburg "soft" site now has three missiles serviced by gantries.

The sites being readied at Warren will be composed of missiles in clusters. These are known as 3X2, 3X3, and 1X9, i.e., 3 clusters of 2 missiles, 3 clusters of 3 missiles, etc. Most of the advanced squadrons have been stabilized in the 1X12 configuration. These squadrons will be "hard."

The Hard Sites—Under this concept the entire ballistic missile and its attendant equipment are supported by a steel crib hung by shock mounts from the reinforced concrete silo. The launching sequence will be as follows: (1) Disengage the shock mounts, (2) Load the liquid oxygen aboard the mis-

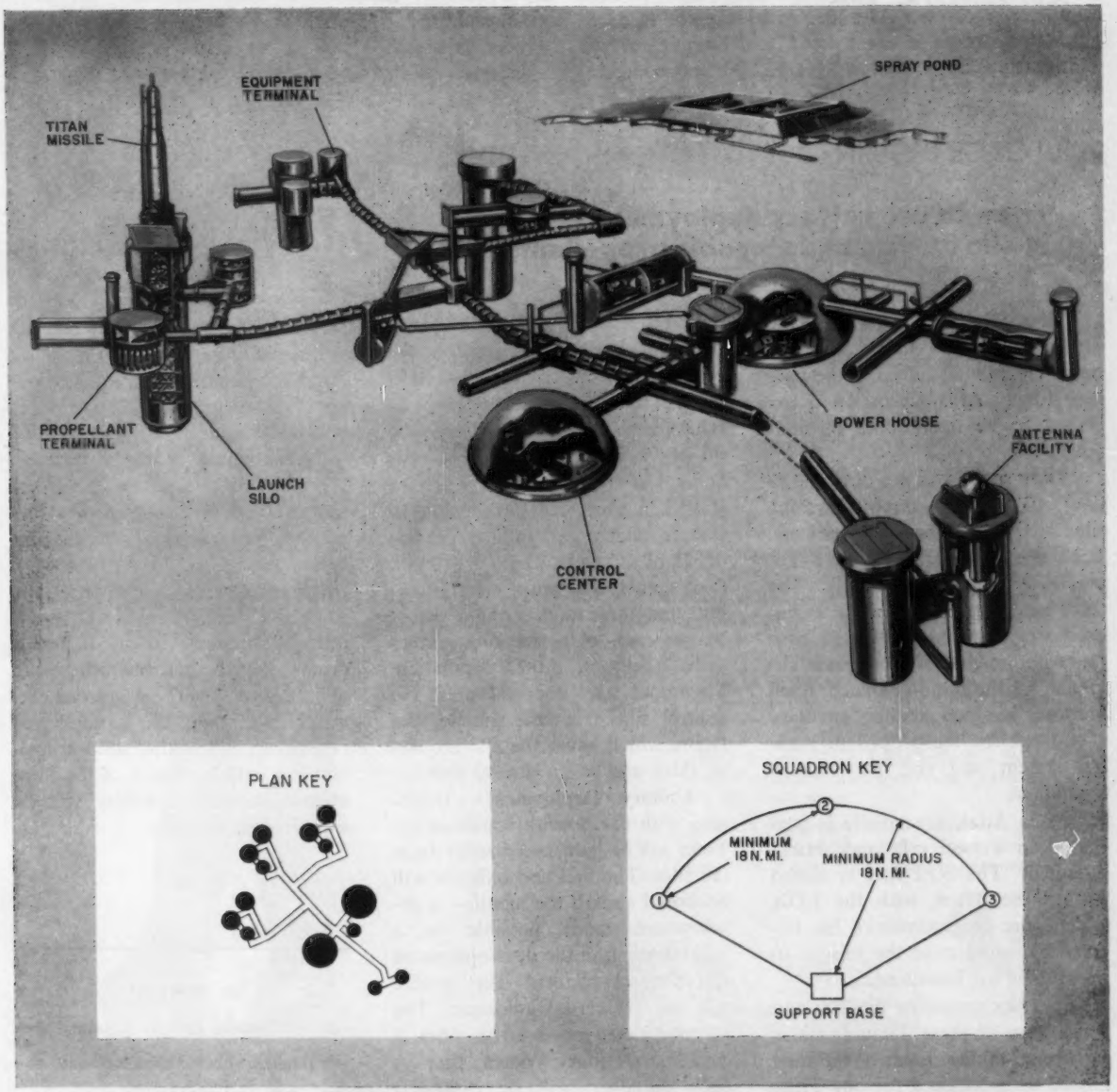
sile, (3) Open the bascule-type doors at the top of the silo, (4) Raise the missile to the surface, (5) Launch. (Ed. Note: Countdown time has been reported at 5-7 min for these sites.)

These later squadrons will also use all-inertial guidance, which will eliminate the vulnerability of radio antennas used in radio-inertial guided Atlases.

The Atlas silo configuration is based on the underground environment planned originally for Titan.

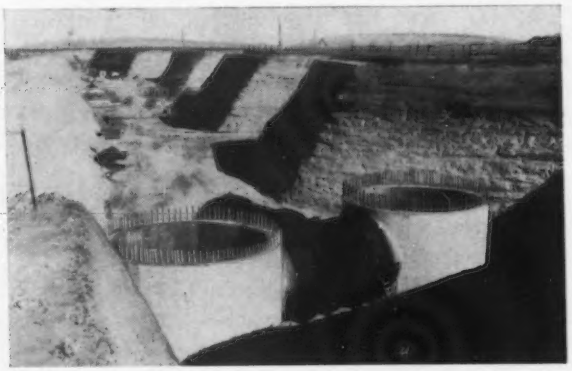
Of course operating missile bases completely underground creates many problems. Heat dissipation from the huge electrical generators is just one of these problems.

All the electrical power for each hard site will be supplied by a 3-phase generator. Linked to diesel engines the generator will power maintenance checkout and launching equipment, measuring and tracking devices, missile and personnel elevators, and fuel loading equipment. Biggest load on the electrical system will be the missile elevator (260,000 lb). One-third of the rated generating capacity will be needed to surface the missile.



TITAN COMPLEX will be completely below ground. Each complex will contain 9 missiles. Three complexes, each 18 mi apart on an arc swung from a central support base will comprise a squadron. Titan II missiles will be fired from silo.

POWER HOUSE for Titan site is constructed of steel reinforced concrete. Area for each complex is excavated, installation is constructed, and base is covered with earth. Each squadron uses 12,000 tons concrete.



ANTENNA HOUSINGS for Titan hard sites takes shape in foreground. Excavated pattern of what will become tunneled passage ways can be seen in background. All inertial Titans will use unitary deployment.

AIR FORCE DIGS IN . . . continued

Titan to use unitary deployment, in-silo launch, and storable propellants

Titan Silos—The first six Titan squadrons are now under construction. The first squadron at the base near Lowry AFB, Colorado, is expected to be operational in mid-1961.

Titan squadrons are designed in the 3X3 pattern—three launching sites with three missiles per site. Each site is separated by an appreciable distance (18 mi). The three launchers at each site are connected by a system of tunnels to a powerhouse, control center, and antennae for the radio guidance. Each launcher has two smaller, auxiliary silos—one for the propellant loading system and one for support equipment.

As in Atlas, the missile is supported in a steel crib and shock-mounted. The RPI fuel is stored aboard the Titan, with the LOX added once the countdown has begun. Elevators raise the missile to the surface for launching.

Statistics regarding the size and complexity of these Titan facilities are breath-taking. Each of the nine missile silos required for one Titan operational squadron has an inside diameter of 40 ft and is deep enough to enclose a 15-story building. Each squadron requires 90,000 cubic yards of concrete, or the equivalent of 350 mi of sidewalk 4-ft wide; and requires 12,000 tons of reinforced steel equivalent to 5,000 mi of ⅝ in. diam reinforced bar. Some 12,000 tons of piping are installed in every squadron in addition to nearly two million pounds of stainless steel. There is 10,000 ft of tunnel, 570 mi of electric wiring, and three underground power houses each of a size sufficient to serve a city of 5,000 population. Mammoth steel doors separate the control silos from the missile silo. Doors which cover the silo are 42-in. thick and weigh several tons.

Unitary Deployment — Beginning with the seventh squadron the Titan will be launched directly from the silo. The fuel and oxidizer will be stored aboard the missile—a development made possible by a breakthrough in the development of storable propellants. The missile will use all-inertial guidance. The planned deployment is on what is called the unitary system; that is, each launcher will be dispersed from the others by several miles.

The first in-silo configuration is now being built at Vandenberg where the feasibility of this concept will actually be tested. All Strategic Air Command crew training exercises on Atlas and Titan missiles will be conducted at Vandenberg.

Minuteman—With Minuteman, AF plans to incorporate hardening, fast reaction, and mobility into deployment concepts. Minuteman reverses the historical trend toward progressively more complex and more costly weapons. It will be deployed not only in hard underground launch sites, but will be put aboard special-purpose railroad cars which can roam the nation's rail networks. Since the solid-propellant is a built-in feature of the Minuteman, launch capability will be measured in seconds.

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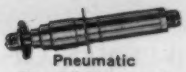


Pneumatic Rise-Off Disconnect

A2F-1 INTRUDER

ANIP Gives Birth

Grumman's low-level attack jet is first "production" plane to bear fruits of Army Navy Instrumentation Program; Endurance, STOL, solid-state avionics are design highlights

By John P. Kushnerick

There is a great deal that is new about Navy's A2F-1. Some of it shows. But, most of it is under the skin in the form of avionics and instrumentation.

The aircraft is the first jet attack plane specifically designed for low-level approach to a target. It is the first Navy aircraft to enjoy STOL capability by deflecting the jet exhaust downward. And, it is the first "production" aircraft to bear the fruits of the ANIP (Army, Navy Instrumentation Program) integrated display cockpit layout.

One thing that is not new about this Navy aircraft is that it is built by Grumman. A2F-1 will represent the 17th combat airframe Grumman has placed in the Navy inventory.

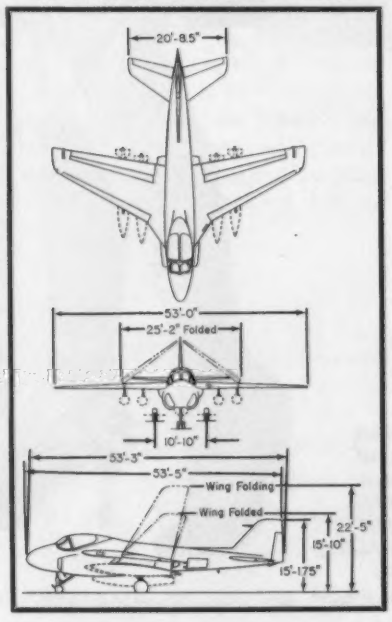
Why ANIP? — ANIP got its start over six years ago. A pilot brushing up on his technique became confused and annoyed over the jumbled maze of instruments in the cockpit. This was not the first time this had happened. But this time the pilot was the Assistant Secretary of the Navy for Air. Immediate action was taken to "clean up the cockpit."

When ANIP got underway several basic ground rules were established. The first was that the problem was too complex and too basic to simply improve on existing systems. 'Uninhibited thinking" had to be used in seeking solution.

Next, it was apparent that aircraft were being designed with little thought to the men who were to operate them. In ANIP the machine was to be designed around the man. The machine was to fit

GRUMMAN A2F-1 is Navy's first low-level attack jet. Two-place aircraft is subsonic, has all-weather capability, and carries estimated 30,000 lb fuel.

INTRUDER SPECIFICATIONS



the special needs and limitations of the man. The machine would handle the things it does best—all the complicated calculation, integration, and correlation of flight data. The man would be concerned only with the tasks he does best.

ANIP has three separate phases:

- Research phase
- Development phase
- Application phase

The program has evolved into a way of thinking — original and penetrating. It has generated revolutionary concepts in display of information to the pilot, airborne computers, microcircuitry, and the man-machine approach.

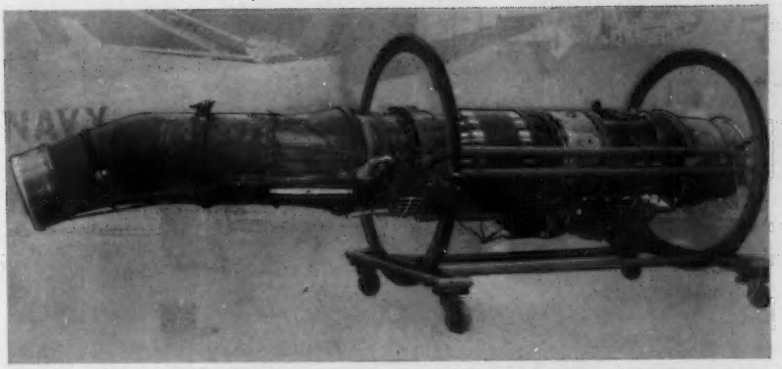
A2F-1 bears many of the "rake-offs" of the ANIP program. But, it is not the ultimate goal of the program. There is still a lot of basic research and information to be gathered before an ultimate operational ANIP system can be fabricated.

Radar Avoidance—A2F-1 has the inhospitable cognomen of Intruder. Its very existence is based on the latest Navy concept that ". . . the only successful approach to an enemy target is one which has as its primary consideration the avoidance of early radar detection." (VAdm. Pirie.)

Intruder will take advantage of the fact that radar is at its least effectiveness against low flying targets. The best radars still depend on the line of sight principle for max range, and confuse ground return with low flying targets. A2F-1 will fly at "low altitudes" and at subsonic speeds.

With an empty weight of more than 20,000 lb and a max gross of over 50,000 lb, about 30,000 lb are left for fuel with max payload aboard. Intruder is powered by two J-52 P-6 engines.

STOL and Long Range—Coupled with good low-level cruise and loitering, is an excellent STOL capability. Navy will use the aircraft from carrier decks—Marines from quickly prepared landing strips.



TILTING TAILPIPE on J-52-P6 gives A2F-1 STOL capability. Pipe tilts downward about 23 deg from wing chordline. Entire pipe is designed and fabricated by Ryan on $500,000 contract.

The design features which enhance STOL are:

- Tilting tail pipe
- Generous wing area
- Large wing flaps and leading-edge slats.

The 30-in. L 605, steel tail pipe incorporates a "ball joint" rig which allows the aft end to be tilted downward about 23 deg. Since the pipe is inclinde about 7 deg from the chord in the full-up position, this gives a max downward deflection of 35 deg.

Tailpipe is also tilted in flight to reduce normal landing speed; it is actuated hydraulically through a switch on the pilot's engine control lever.

Design and fabrication of the tailpipe is done at Ryan under a $500,000 research and development contract from Grumman. Ryan is using explosive forming techniques on sheet material about 0.063 in. thick. Dimensional tolerances are 0.02 in.

During takeoff, pipe is actuated to give added lift for shortening the takeoff. Project Engineer Larry Mead suggested this will be standard operating procedure. Exact configuration and technique is still being optimized. Wind tunnel tests give good results with this technique, field varification is next step.

Wing area is about 530 sq ft; span is 53 ft. The outer 27.8 ft of each wing is hydraulically folded.

Leading-edge slats are actuated by screwjacks that are driven through a gear box centrally located in the fuselage. The gear box is powered by an hydraulic motor. A mechanical locking device connects inboard and outboard sections of the slat on each wing. Hence, the slats are operated as singular units during flight.

Wing flaps are near full span and are of the slotted Fowler type.

Powerplant Design—The set of J-52P-6 powerplants contributes to extended loitering, long range cruise, and STOL. Produced by Pratt & Whitney it is under heavy security wraps. Each engine gives 8500 lb of thrust. (Another version of this engine is used in Hound-Dog.) Engine accessibility and interchangeability are important design features of the aircraft. Large access doors allow ground personnel to change any engine accessory while the engine is installed in the airframe. Accessories are laid in such a way that engines can be interchanged in right or left "nacelles."

No special ladders or work platforms are necessary for normal preflight. Almost 60 per cent of total fuselage area is access doors. This is highly desirable for field service but has caused some fit problems during manufacture. Doors must be interchangeable.

Avionic gear and cockpit display system are still highly classified. The bulk of the gear is used in a system called DIANE (Digital Integrated Attack Navigation). This

Litton and Kaiser avionics mark revolution in cockpit display

is one of the most sophisticated weapon delivery systems yet devised. DIANE is the heart of the airplane. It incorporates:

- Automatic Bomb/Nav. System.
- Low Level Terrain Avoidance.
- Cockpit display system which allows pilot to see target day or night and in any kind of weather.

The cockpit display system and the bomb/nav gear are the first production outgrowth of ANIP. Display provides vertical and horizontal situation information, and is closely akin to "ribbon in the sky." The DIANE system is all transistorized except for cathode display tubes.

Litton Industries' Electronic Equipments Div. and Kaiser Aircraft & Electronics are supplying a large share of the avionics for A2F-1.

Litton's equipment includes the digital subsystem, the central DIANE computer, and the inertial navigation subsystem.

The DIANE computer integrates the other avionics equipment by performing calculations for navigation, weapon delivery, course control, radar search and tracking, autopilot, and provides display situations for the radar operator and pilot.

ANIP Rakeoffs—The computer makes use of the following:

(1) Logic—High speed arithmetic unit in conjunction with whole number, general purpose logic.

(2) Systems Analysis—Hybrid navigation system combining dead reckoning, doppler and inertial. Cruise control including fuel management.

(3) Special Components—Magnesium memory drum with contact heads. Germanium/silicon transistor circuits, modified for production units. Flatcard packaging modified to be used with laminated wiring. NADC shaft encoders for selected inputs and outputs.

(4) Ferrites — Airborne core scratch pad memory of 128 words with a four microsecond read-write cycle.

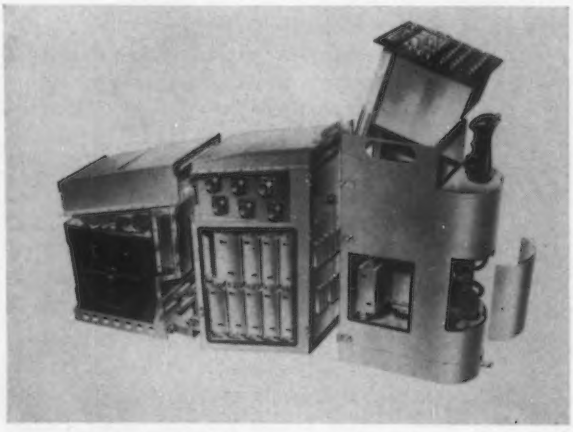
The inertial subsystem in A2F-1 is comprised of Litton's inertial platform and associated electronics. In conjunction with the DIANE computer it can furnish information on aircraft position in the various modes of navigation with high accuracy.

Litton also makes ground checkout equipment for A2F-1. Its "adapter" allows Litton equipment to be used with BACE (Basic Automatic Checkout Equipment). This is a big dollar contract.

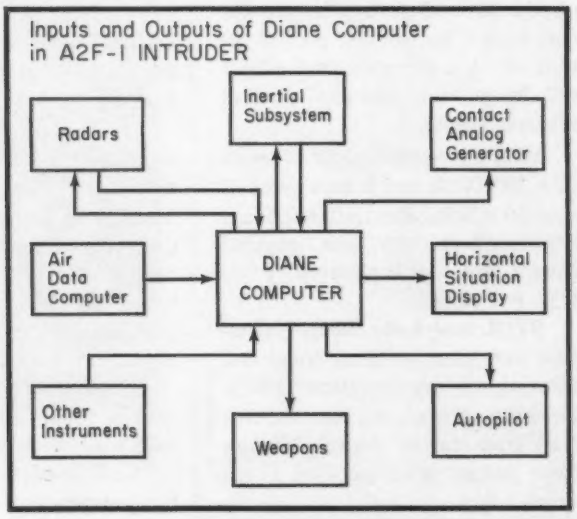
Vertical Display—Kaiser is under subcontract to Grumman to develop the vertical display system.

This avionic system electronically provides the pilot with visual cues to maneuver the aircraft without conventional instruments and without visual contact with the ground. It provides elemental definition of ground and sky. It also features the display of target symbols. Although it is the goal of ANIP to provide a system that would give real world definition of ground texture and flight path, it is not known if the A2F system is this advanced. The system does give a 6 deg of freedom stabilized flight path.

Except for the 8-in. cathode ray display tube the system is all transistorized. Intent from the outset was to use a transparent phosphor



CENTER PEDESTAL unit for DIANE computer in Intruder is shown in artist concept. Bomb/nav system is outgrowth of Army Navy Instrumentation Program.



tube to gain max contact ratios.

The A2F-1 vertical display system is entirely self contained in a single assembly. It is 8-13/16 in. wide, 7¼ in. high, and 23 in. deep. Weight is approximately 50 lb.

The system is known to be similar in many respects to gear supplied late last year to NADC Johnsonville for flight test.

NADC's system uses about 300 silicon transistors. It develops a quasi-random-textured surface for earth, and flight path display is much more complete than anything developed to date. Motion perspective, one of the more difficult things to achieve electronically, has been demonstrated to a degree.

Equipment meets the material requirements of MIL-E-5400 and the environmental requirements of MIL-T-5422.

Other companies known to be engaged in A2F avionics are: Chicago Aerial Industries, which makes the gun sight head, Norden Div., United Aircraft, General Electric Co., and Varo Mfg. Co.

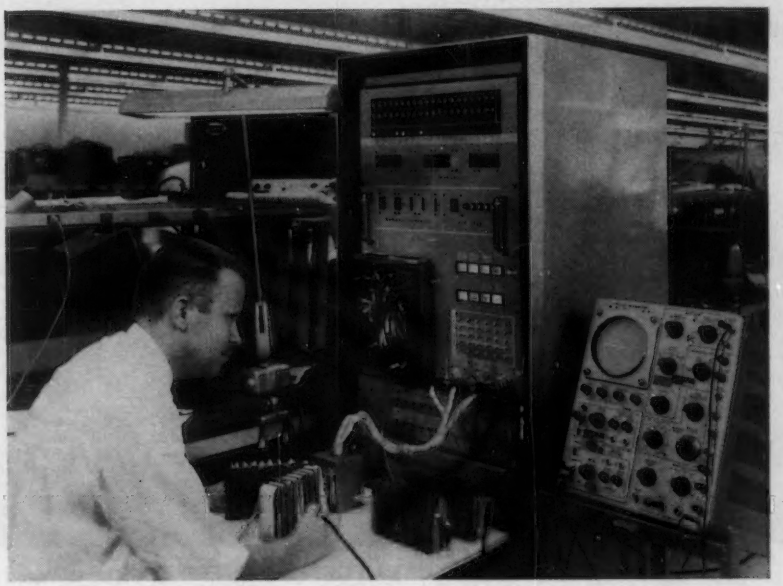
A2F DESIGN NOTES

STRUCTURAL

- "Fatigue proof" structure that can operate at high speeds in rough lower atmosphere.
- Brazed titanium honeycomb speed brake which sits in jet exhaust.
- Fuselage longerons of stainless steel.
- Wet wings with large integrally stiffened skins: chemically and machine milled.
- Large radome, produced by filament winding.

SYSTEM FEATURES

- Aircycling systems cools both pilot and electronic gear.
- Electrical system is all AC, bulk of which is 400 cycles.
- Flight controls are power actuated by tandem cylinders.
- Escape system is modified Martin Baker seat.
- Inflight refueling capability is included.



TESTING AT LITTON, who designs and builds computer and other avionics, is done on one of three computers produced in last 15 months. Computer is heart of aircraft.

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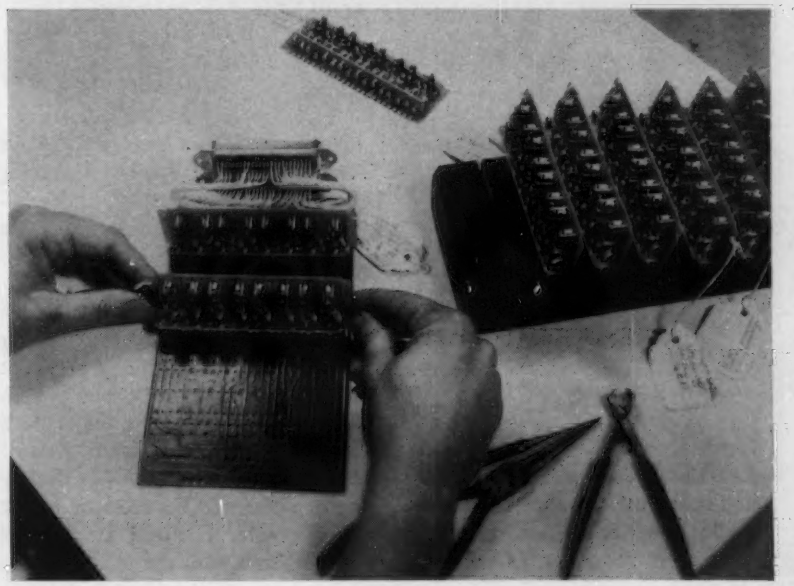
ELECTRONIC PACKAGING in Litton produced instruments makes use of ANIP developed etched-wire circuit card. A2F-1 avionics are highly transistorized with germanium/ silicon units.



RECOVERY OF SATURN BOOSTER is to be effected by LSD (Landing Ship Dock). Sea impact will be lessened by parachutes and retrorockets. Booster will be floated aboard.

Controlling Corrosion In Saturn

NASA plans recovery and reuse of huge space booster Does corrosion block the way?

By V. R. Larson, and D. S. Hirshfield
Advanced Design Subdivision
Rocketdyne, A Div. of NAA, Inc.

The giant Saturn's first stage is the first rocket booster to be engineered for recovery and reuse.

A system of parachutes and retrorockets will slow descent to the sea and reduce landing impact. This system was chosen because it requires least changes in present booster designs. It is also least expensive.

The floating booster will be floated aboard a Landing Ship Dock (LSD) and returned immediately to land-based maintenance facilities.

But the effects of salt-water corrosion will be heavy in even the most expeditious recovery. As a result, extensive studies are being conducted to understand and minimize corrosion mechanisms in rockets.

Predicted Corrosion—The corrosion rate of carbon steel or iron continuously immersed in sea water under natural conditions is about 0.005 in./yr. This value is generally independent of salinity. Data derived from long-duration tests of iron and steel show surprisingly small differences in rates of attack by sea water obtained at different points throughout the world. However, the average rate suggested does not take into account the more severe effects of localized corrosion in the form of pitting. The extent of this corrosion damage must be determined by visual and microscopic means. Moreover, this rate does not represent the more severe effects of alternate and partial immersion, which greatly increase the severity of corrosion.

Corrosion-resistant steels are normally nonreactive (passive), but when immersed in sea water devoid of oxygen (i.e., in a nonoxidizing medium) they become active.

However, for exposure times of 4 to 12 hr, and with the normal oxygen content of sea water, this problem of active Cres steel probably will not occur. Alloys such as steel alloy 316, which contain 2 to 3 per cent molybdenum, have especially good resistance to sea-water attack. Presence of molybdenum strengthens the passive oxide film and improves resistance to halogen salts in sea water. Action of molybdenum may be described as producing increased nobility as well as passivity, greatly improving the resistance to pitting and stress corrosion. Galvanic corrosion in an engine can occur whenever a metal part is in electrical contact with a metal of higher nobility and is exposed to a good electrolyte, such as sea water. Many engine components would be subjected to these conditions. For example, galvanic corrosion at the expense of aluminum will occur when aluminum and steel are in contact and immersed in sea water. Best means of preventing this type of corrosion is to provide an insulating barrier of exceedingly low solubility between aluminum part and its environment. This can be done by coating the metal surface with a corrosion-resistant, non-reactive film. Resultant surface coating must be compatible with the engine propellants. Anodic treatment of aluminum is considered the best approach in this respect. When properly prepared, an anodized coating displays relatively high resistance to corrosion, and provides high electrical insulation to underlying metal.

Cathodic protection, which minimizes galvanic action on protected parts by altering electromotive potentials to induce corrosion in auxiliary expendable materials, is not considered feasible in rocket engines. It appears impracticable to attach to the engine the many auxiliary anodes and batteries necessary for complete protection.

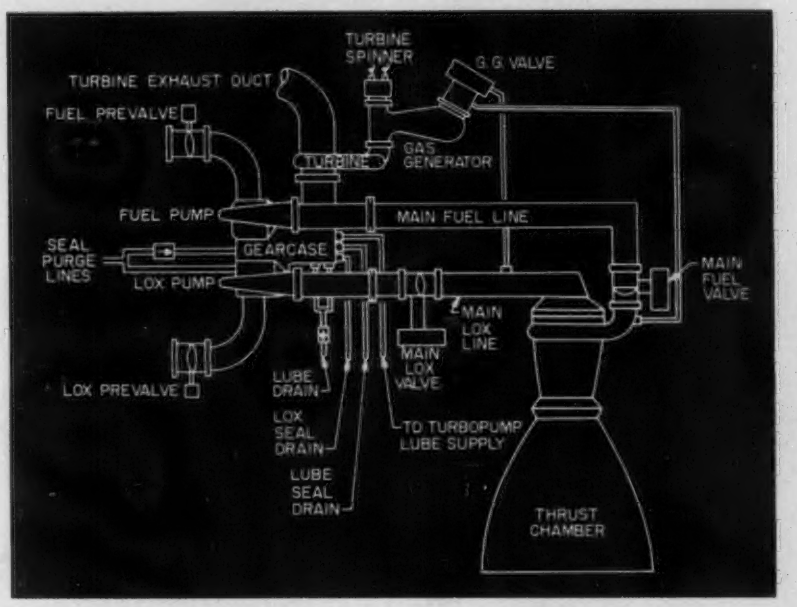
Intergranular corrosion of stainless steel is, primarily, the result of precipitation of chromium carbide at the grain boundaries. Stainless steels used in rocket engine construction are stabilized by titanium or niobium to minimize this type of corrosion. During the brief sea-water exposure expected for the engine, significant intergranular corrosion is not expected to take place.

Sea Water Corrosion—Extent of sea-water corrosive action has been investigated at Rocketdyne by laboratory testing of rocket engine components and materials. Water from the Pacific ocean has been used in all the tests. A series of four-hour immersion tests was made on various component parts for ten cycles, giving a total of 40-hr immersion in sea water. At the end of each four-hour immersion period, parts were inspected for corrosion deposits. Parts were then rinsed with distilled water and examined for pitting. Test results for engine components typical of those tested are listed in adjacent table.

Component materials other than aluminum were heated, in increments of 200°F, from 200 to 1000°F, and immersed in ambient temperature sea water for a four-hour period to determine if increased corrosion or thermal shock damage resulted. Aluminum parts were heated to 200 and 400°F and subjected to the same test conditions. All parts were found to be acceptable with respect to corrosion and thermal shock resistance, indicating that aerodynamic heating should not affect the corrosion problem.

In general, lab tests indicated that, with proper precautions, all major components will satisfactorily withstand four hours of immersion in sea water. Partially immersed specimens showed more corrosion than those totally immersed. The tests further indicated that all electrical wiring, thermocouples, etc., may have to be replaced in spite of precautionary protective coatings applied prior to assembly. Tests have also shown that rinsing the engine with fresh water will be necessary immediately after recovery. Total immersion in a corrosion-preventive fluid should follow as soon as practicable for a minimum of two hours.

In addition, aluminum parts may require protective coatings, such as hard anodizing; chemical conversion coatings which can be applied by dip, brush, or spray, will



SIMPLIFIED SCHEMATIC of H-1 engine which will be clustered in Saturn booster shows elements which are subject of corrosion studies.

Immediate rinse with "fresh" water and dip in oil preservative desirable

produce a corrosion-resistant film on aluminum and its alloys, and could also be used. Alodine and Iridite satisfy these requirements.

Salt Spray—The damaging effects of wave action, sea spray, and periodic immersion on rocket engines warrant a review of the salt-spray corrosion tests performed on rocket engines. The conditions and the results of several tests of typical engine components are summarized below:

Duration—50 hr.

Test chamber temperature —95°F.

Spray deposition rate—1.25 to 1.85 ml/hr.

Salt solution strength—20 per cent NaCl—ph-7.0.

In one such test, a gas generator assembly consisting of a Cres steel body, a copper injector, an aluminum adapter, a Cres steel cover, and a cast aluminum valve body was subjected to the salt spray. After the test, the Cres steel body showed oxidation on all surfaces. In the valve, salt spray had penetrated into the actuating mechanism and rendered the microswitches inoperative.

No evidence of galvanic activity was noted between copper injector and stainless-steel body of specimen. Interior and exterior surfaces of valve indicated no corrosion, and except for the inoperative microswitches, subsequent functional tests were satisfactory.

Salt-spray tests have also been performed on a Cres steel heat exchanger coil. Although rust formations appeared on the coil, it was successfully pressure tested after the salt-spray tests. An anodized valve salt-spray tested indicated that the anodized surfaces were corrosion resistant.

Another salt-spray test was conducted on a 1000-lb thrust vernier engine system, previously test fired for over 5000 sec. After test, the engine showed a fairly uniform dustlike coating of salt particles on its exterior. A number of small rust spots resulted inside the chamber from the throat to several inches upstream, and several small corrosion areas were evident around the fuel manifold at chamber exit.

Following the test, the injector and LOX dome were removed and cleaned; the LOX bleed valve was found to be inoperative, and was replaced. The chamber pressure switch, which did not operate as required, was also replaced. Examination indicated internal corrosion and a short circuit in the electrical system.

The engine then successfully underwent 16 hot firing tests, accumulating an additional 1250 seconds of satisfactory operation.

Salt-spray tests on engine components did not indicate severe damage. The relatively light damage that did occur in these tests must be evaluated in view of the 50-hr test period, which is considerably longer than the expected duration of ocean recovery.

Recovered Rocket Engines—To determine the extent of corrosion on complete rocket engines immersed in the ocean, engines were recovered and examined from two Thor missiles, whose flights were prematurely terminated. One engine was recovered off Cape Canaveral from the ocean bottom after approximately 24 hr. Silt and sand were present on the engine components. No attempt to clean the components was made prior to examination. Several aluminum component housings were ruptured, the thrust chamber was crushed, and the turbopump was broken.

Second engine was recovered off Vandenberg Air Force Base after resting on ocean floor at a depth of 145 ft for 17 days. This missile had been destructed after launch at approximately 40,000 feet. In both cases, the impact velocity of the engines was far greater than that anticipated in a programmed booster recovery using deceleration devices. As a result, both engines were damaged at ocean impact.

Thrust chamber of the second engine had been twisted on impact but had not collapsed. Nickel thrust chamber tubes and steel thrust chamber bands for both engines were in excellent condition; aluminum paint seemed to prevent corrosion and discoloration. The steel thrust-chamber reinforcing hoops, also covered with aluminum paint, had some evidence of discoloration and corrosion, but the hoops had a higher degree of scratching and thinner aluminum paint covering than tubes and bands. Steel fuel-

TYPICAL PARTS IMMERSED IN SEA WATER FOR TEN 4-hr CYCLES

Part	Material	Appearance
LOX Dome	Aluminum	No harmful effects
Injector (section)	Copper, 4130 steel, Cres screen	No harmful effects
Thrust Chamber (section)	Nickel tubes and brazing material	No harmful effects
Turbopump LOX Volute	Aluminum	No harmful effects
Turbine Nozzle Segment	Hastelloy "B"	No harmful effects
Turbopump Gear Shaft	4130 steel	Corrosion on shaft, slight corrosion on wheel
Turbine Shaft Sleeve Flange	1020 steel plate	Slight rust, no harmful effects
Bearing	SAE 52100 steel Synthane cage	Inoperable; failed after 2 cycles (8 hr)
Gas Generator Body Combustor Assembly	Cres steel plate and sheet	No harmful effects
Head Suppression Valve Housing	2024T4 aluminum	White corrosion products

inlet manifold had minor corrosion and discoloration, but not to the extent that would have prevented reuse.

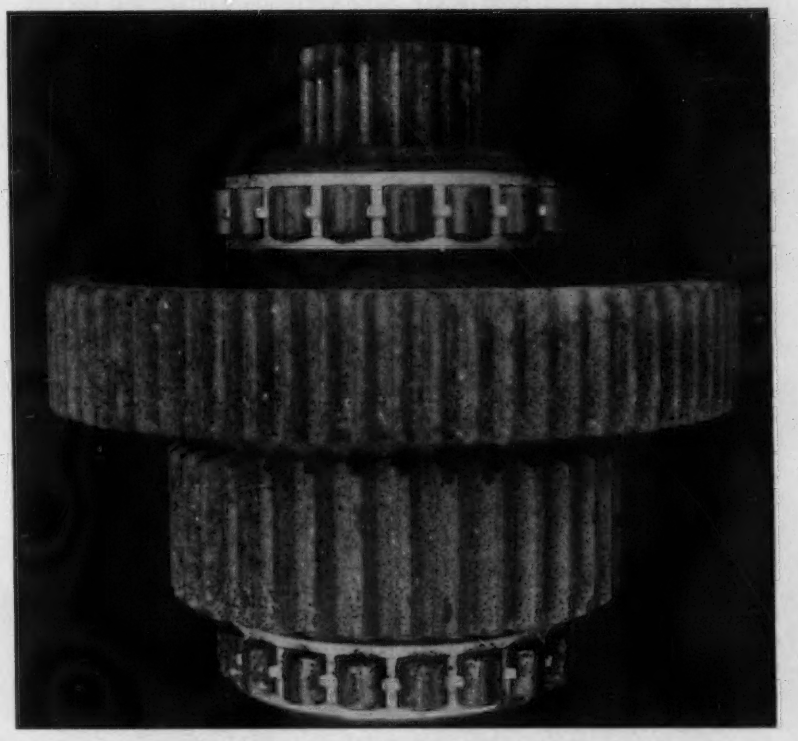
Steel thrust-chamber injector of the Vandenberg engine showed evidence of surface corrosion and discoloration. Combustion chamber side appeared more corroded than the LOX dome side. However, the corrosion did not appear to prohibit reuse after adequate cleaning. Also, there was evidence of silt and sand in various parts of injector. The unanodized aluminum LOX dome had an over-all surface coating of white aluminum oxide, but with adequate cleaning, it would have been reusable.

Impact Damage — Turbopump of first engine exhibited extensive impact damage, but only minor corrosion damage. Corrosion was evident on unanodized aluminum pump inducer and pump impeller. Turbine nozzle wheel and blades showed surface discoloration and minor corrosion. Corrosion damage would not have prevented reuse of these items if adequate cleaning had been provided. Gears and bearings were corroded to the extent that they could not be reused. However, they were in direct contact with seawater; this will not be the case in a planned recovery.

Turbopump of second engine exhibited no apparent evidence of sea-water in its gearcase. Gears and other hardware inside the gearcase were in good condition. The accessory drive gear, after cleaning, indicated surface corrosion and pitting which would have prohibited reuse. The unanodized aluminum pump impellers and pump housings were in good condition, and could have been reused.

A main fuel valve in the second engine had been completely disassembled and cleaned prior to examination. The valve housing and blade, made of unanodized aluminum, showed no evidence of corrosion damage after cleaning. Valve actuating mechanism showed a slight discoloration after cleaning, indicating sea water entry into actuating mechanism through the blade-

IMPACT DAMAGE on turbopump of recovered Thor engine was extensive. Corrosion damage was minor. Unanodized impeller showed greatest corrosion effects.



TURBOPUMP GEARS recovered from engine which impacted in the sea show some corrosion effects. Rinse in fresh water and immersion in oil greatly reduces corrosion on most parts.

Hard anodizing aluminum parts recommended in Rocketdyne corrosion study

shaft seal. This effect is not anticipated in normal ocean recovery, and was probably due to hydrostatic pressure at ocean floor. The valve was in usable condition after cleaning. The Cres steel gas generator housing of the engine experienced corrosion on its outer surface, but inner surface was protected by carbon deposits, and was not corroded. The copper gas generator injector seemed in relatively good condition, although some surface corrosion existed. Adequate cleaning would have permitted reuse of both items. The tubular steel engine structural members were in reusable condition. Where surface paint was scratched, corrosion occurred, but not to the extent of preventing reuse.

A general conclusion reached from examination of these parts is that if the parts had been water rinsed and immersed in preservative oil upon recovery, corrosion damage would have been minor. Analysis of all the data derived from examination of recovered engine makes possible the following general comments: Galvanic corrosion was evident on most of the various components where steel bolts held aluminum parts together and where dissimilar metal washers or gaskets were used. Bolt holes in aluminum components having steel bolts were not corroded to the extent that the components could not have been reused. Corrosion of anodized aluminum parts appeared extremely minor.

Internal Contact — There are two primary paths of sea-water entry into the engines: the thrust chamber, and the turbine exhaust duct. After the ocean impact, sea water will enter the engine through the thrust chamber and become entrained in: (1) injector, (2) thrust chamber fuel manifold, (3) thrust chamber cooling tubes, and (4) fuel and LOX secondary lines.

Main fuel valves (and the prevalves), which are closed at engine cut-off, will prevent sea-water entry into the pumps through the main propellant ducts. The corrosion tests and examination of the two recovered rocket engines have indicated that no damaging corrosion will occur to the thrust chamber tubes or to the secondary system lines. They will have to be flushed after recovery, but indications are that these components will not require replacement. Thrust chamber injector also will be reusable after flushing.

Sea water, entering engine through turbine exhaust, will come in contact with turbine and with the seal between turbine and gearcase. Turbine wheels and blades are fabricated from corrosion-resistant steel, and tests have indicated that no corrosion damage will occur to these components.

If sea water entered gearcase, through the turbine-to-gearcase seal, service and maintenance of turbopump gears and bearings would be required. To prevent sea-water entry into gearcase through the turbine-to-gearcase seal, the gearcase can be flooded with fuel prior to ocean impact. Gearcase could be flooded using the residual fuel trapped in the main fuel line; propellant-tank pressure could be used for flooding, and a check valve in fuel line would prevent backflow. Thus, any possible sea-water entry into gearcase could only occur after depletion of contained fuel, which would be unlikely.

To prevent sea-water entry into gearcase, through the LOX pump-to-gearcase seal, check valves have been placed in the seal drain lines. This eliminates backflow and provides a simple and effective means of protecting the turbopump.

Examination of the two recovered gas generator injectors (which are made of copper and which, in the engine, are in contact with aluminum housings) has indicated that galvanic corrosion occurring during a short immersion period would not prevent component reuse. However, should further experience indicate corrosion protection to be necessary, the aluminum housing could be hard anodized and the exposed part of copper injector could be chromium plated. These processes would involve no modification of the present system design.

Hard Anodizing—In fact, hard anodizing of all aluminum parts and components in engine system is desirable, and promises to reduce greatly the galvanic corrosion and oxidation throughout the engine. Similar benefits can be obtained using corrosion-preventive chemical coatings, such as high-temperature paints on the steel components of engine. Complete closing off of the turbine exhaust duct and the thrust chamber before ocean impact is another possibility. This would require certain design changes but would allow postrecovery flushing and servicing to be reduced to a minimum.

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This article is based on a paper presented recently at the ASME Aviation Conference.

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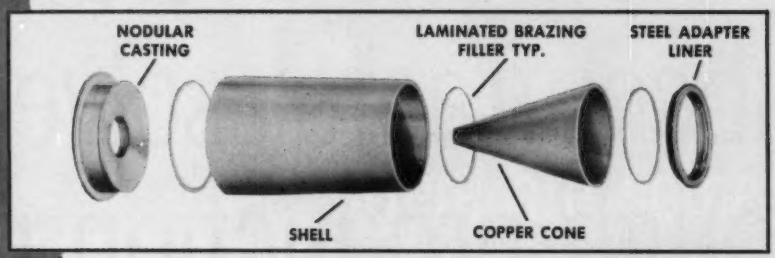


The four components of the nose assembly—nodular iron casting; low-carbon welded steel canister which measures 34" long, 15½" diameter at one end and 17¾" at the other; spun copper cone and low-carbon steel ring. The thinner rings are Easy-Flo 45 wire braided for precise alloy position and control.

Martin Develops New Induction Heating Methods to Braze Lacrosse Missile Assembly With EASY-FLO 45

One of the largest assemblies yet brazed by induction-heating techniques is a section of the Lacrosse missile being manufactured at The Martin Company's Baltimore Division. During development, one problem was posed by the variety of metals used. First it was necessary to braze a low-carbon welded steel canister and nodular iron casting. Then, to complete the assembly, a spun copper cone and low-carbon steel ring were joined to the canister. An induction coil was designed by Martin to accomplish this critical operation. Temperatures had to be restricted between 1300 and 1350°F to prevent a transformation change to the crystalline structure of the nodular iron. Martin's Materials Engineering Laboratory made careful examinations of this assembly and found that Handy & Harman Easy-Flo 45 Silver Brazing Alloy and B-1 Flux make possible the strong, uniform joints necessary to meet the stringent requirements the Company has set. Its low-working temperature, high strength, fast penetration and flow characteristics are only a few of the features which make this brazing alloy ideal.

More and more aircraft and missile components are being made with the aid of Handy & Harman silver brazing alloys and flux. The products described here are just two of the many available to help solve your problems...make your job easier and quicker. For a more complete picture of silver brazing and the advantages it offers you, write for your free copy of Bulletin 20.

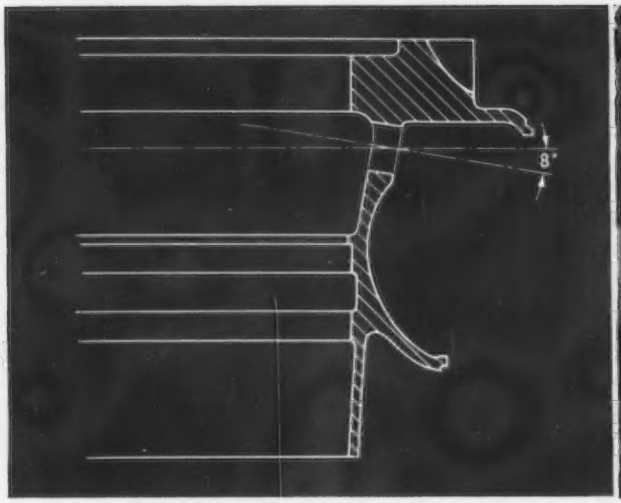
Your No. 1 Source of Supply and Authority on Brazing Alloys

HH

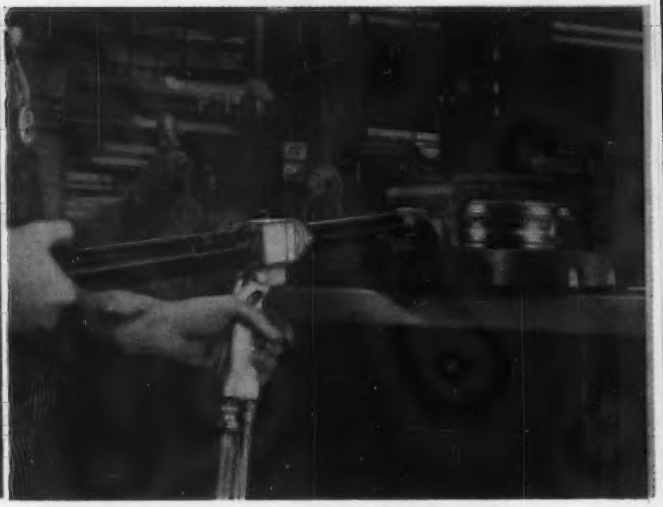
HANDY & HARMAN

General Offices: 82 Fulton Street, New York 38, N.Y.

How one aircraft parts subcontractor solved a tough production problem



Sectional drawing showing the inclination of hole at 8° to center line. Center lines of holes are required to be true within .010".



Close-up of Broach Gun, jig and fixture, showing ease of operation.

PROBLEM: MAKE 90 HOLES .281" SQUARE IN 13" DIAMETER STAINLESS STEEL RING TO ±.005" TOLERANCE

SOLUTION: USE CP PORTABLE BROACH GUN AND AN INEXPENSIVE FIXTURE

B. H. Aircraft Co., Inc., of Farmingdale, N. Y., is making a missile engine thrust chamber component for a major engine manufacturer. The problem of producing such close tolerance square holes could have been a major stumbling block. However, by using a CP Portable Broach Gun and a simple jig and fixture, these components are being produced in quantity with ***never a reject!***

Right: Broaching operation at B. H. Aircraft Co., Inc., showing simple jig and fixture. The portability of the CP Broach Gun and its self-contained Power Cell makes this an easy one-man operation.

Chicago Pneumatic 8 East 44th Street, New York 17, N. Y.

PNEUMATIC TOOLS • ELECTRIC TOOLS • AIR COMPRESSORS • DIESEL ENGINES • HYDRAULIC TOOLS • AVIATION ACCESSORIES

Completed part, with broach used to finish holes to .281" square.

Here are some of the things you can do with the NEW CP Portable Broach Gun

CONVERT ROUND PILOT HOLES TO THESE SHAPES:

- SQUARE
- HEX
- OVAL
- SPLINED
- KEYED

Using the CP Portable Broach Gun gives you a completely new technique in broaching. You take the tool to the work. Broach is inserted in round pilot hole and one squeeze of the trigger forms and finishes the hole. The broach pulls a clean, mirror finished hole, every time to ± .0002" accuracy. Self contained CP Power Cell weighs only 58 pounds, operates on shop air lines and furnishes oil pressure up to 7,000 psi.

Automatic Tester Keeps B-58 Mission-Ready

Flight-control system is checked on go-no-go basis by Bendix tape-controlled mobile test set, in few hours; Malfunction isolated to smallest flight-line replaceable unit

By S. Peter Kaprielyan

The paradox of aerospace weaponry demands that extremely complex systems be kept mission-ready by semi-skilled operators. This means that weapon systems must be supported by checkout equipment leaving little to individual's discretion.

Flight control system of Convair's B-58 uses such a computer-tester which runs through 750 static and dynamic tests in several hours. This is a mobile tape-controlled unit made by the Bendix Support Equipment section of The Bendix Corporation. Earlier checkout procedure required two days' work by three men just to make spot static-tests.

Tester determines operational capability on a go-no-go basis, and isolates malfunction to the smallest flight-line replaceable component.

Major constituents of the testing system include: a trailer, three surface-motion transducers, a portable subcontroller assembly for cockpit use, and an intercom system.

Trailer — Van-type four-wheel trailer houses the electronic modules or chassis, as well as, all the subelements of the testing system: cabling, surface-motion transducers, subcontroller, and entire intercom system.

Surface — Motion Transducers —Three such units are provided: Two for mounting on elevon surfaces, and one on the rudder. Transducers measure the positions of control surfaces and convert this information into electrical signals.

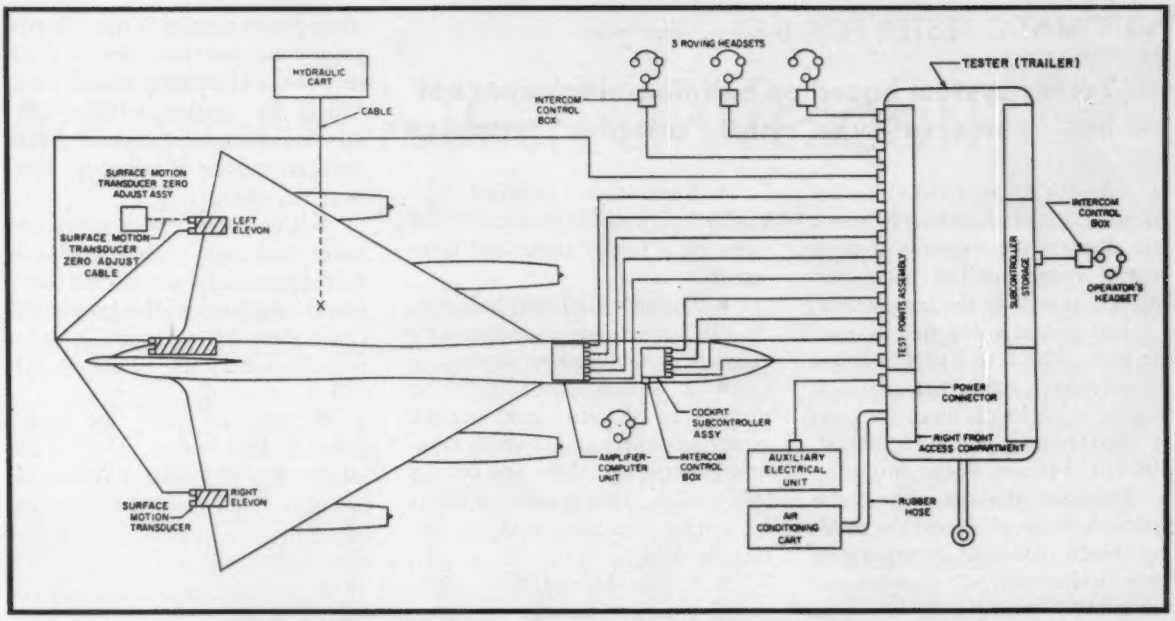
AUTOMATIC TEST SET consists of electronic modules or chassis housed in a four-wheeled trailer. Mobile unit also contains all metering, switching controls and cables needed for checkout operation.

Subcontroller Assembly — This is a portable unit placed within the cockpit to instruct cockpit operator to set the position of aircraft controls and switches, and to read the indicators. When test system is in the automatic or single test mode, subcontroller may be used to operate the entire system from the cockpit.

Intercom System — Five headsets, connected to tester, make up the intercom system; all headsets can be used simultaneously.

How System Works

- Coded test information, read from punched tape, is fed from tape reader to programmer.
- Using this information, programmer supplies command signals throughout the set.
- Input simulator sets voltage level for various inputs; input selector routes these inputs to proper terminals on amplifier computer in aircraft.



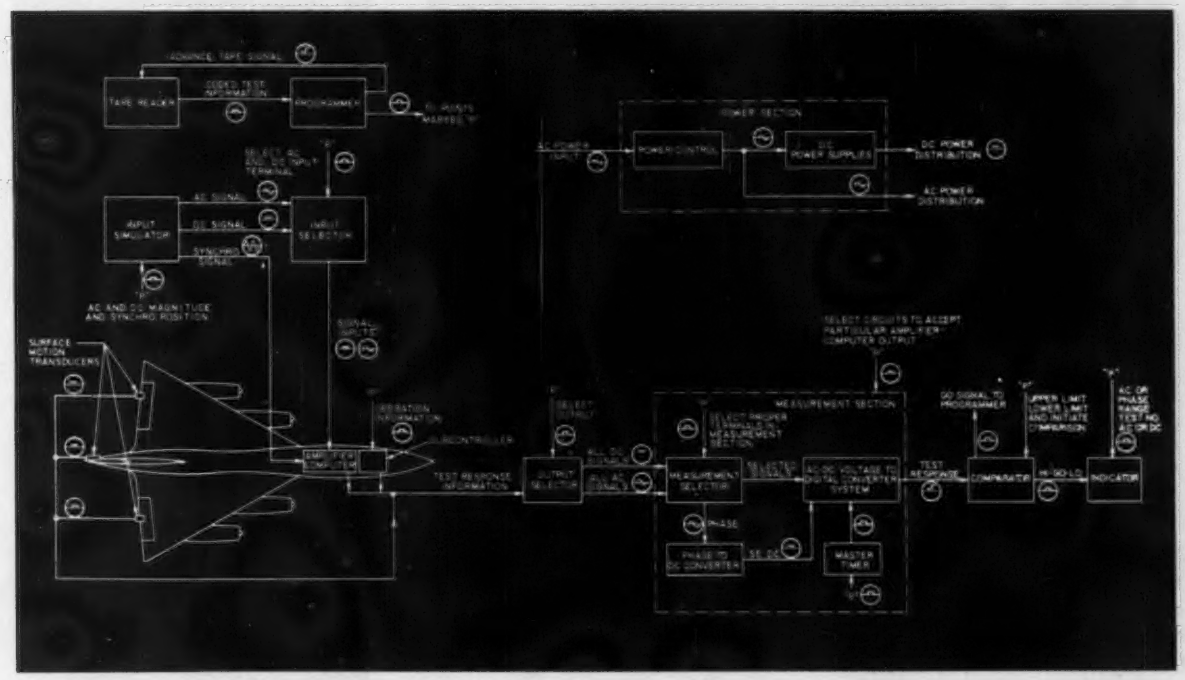
CABLE DIAGRAM shows connections between tester, aircraft, electrical and hydraulic power-supply carts and air-conditioning cart.

• Desired output signal, from aircraft, is chosen by output selector; signal is then fed to measurement selector and routed through proper measurement channel (a-c voltage, d-c voltage, or phase).

• Signals are measured, converted into digital information and applied to comparator.

• Comparator compares between measured signal and programmed upper and lower limits to determine whether signal is within tolerance.

• Comparison results appear



FUNCTIONAL BLOCK DIAGRAM, in simplified form, shows how tester operates. Checkout system performs complete flight-line test of automatic flight-control system from a prepunched tape.

Tester system based on building-block concept has "universal-type" and "adapter" modules

on indicator as HI-GO-LO or polarity NO-GO indication. Indicator also displays the response of flight control system, to test being performed, as well as the test number.

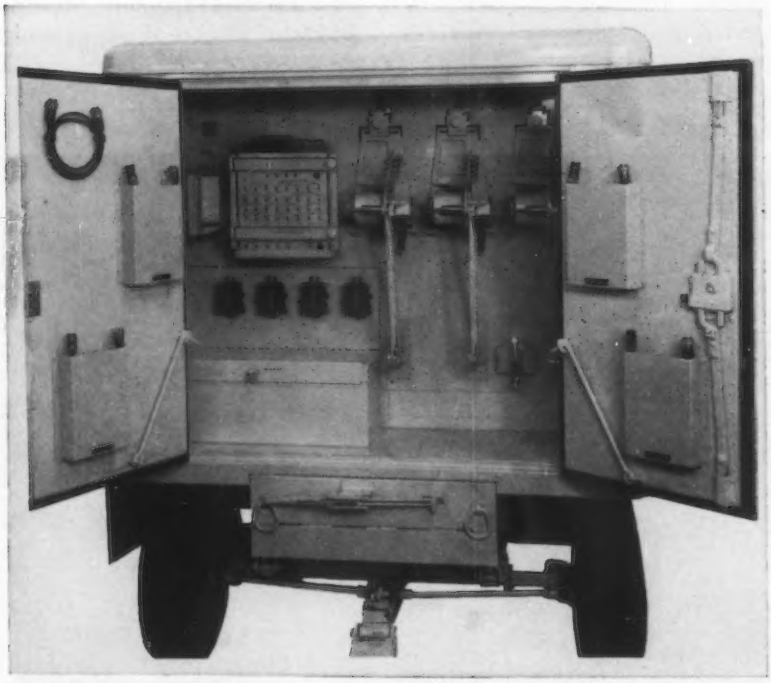
Test system is designed to operate from −20°F to 130°F ambient temperature; otherwise, external heating or cooling is used. Its power requirements are: 115/200 V, 400 cps, 3-phase, 4-wire current.

Universal Modules—The entire system is designed around the building block concept, incorporating both "universal-type" modules and "adapter" modules. Universal modules perform the following functions:

- Eight-hole punched-tape reader operates automatically and stops on a line at prescribed commands.
- Transistorized odd-hole parity checker safeguards against dirty contacts or faulty photo diodes.
- A silicon diode decoding matrix feeds into transistorized power amplifiers and converts tape-hole patterns to address and decode information. This provides a 1024-bit storage capability with no further decoding.
- A four-decimal digit, high-speed analog-to-decimal converter forms the heart of the system.
- Programmable solid-state triple-preset counter is used to program time and time delays when required, and develop encode commands for analog-to-digital converter. Triple-preset capability prevents acceptance of erroneous transient responses.
- Comparator, with upper and lower limit logic circuits, compares the programmed limits against coded output of converter. Magnitude decision shows HI, GO, or LO, and if polarity is incorrect, a Polarity NO-GO is indicated.
- Indicator routes the binary coded decimal answer, stored in the selected flip-flop bank of converter, to a decoding circuit where it is reduced to decimal equivalent. These drive indicating tubes.
- Power supply and power control modules contain the d.c. power and controls needed to operate and monitor power for checkout system.

Addition of adapter modules to the universal ones customized the checkout system for the B-58. The following adapter modules were developed for this purpose: Two programmable voltage (a.c. & d.c.) simulators; two synchro simulators; an input selector; an output selector; a cockpit subcontroller and subcontroller storage; and three surface-motion transducers.

The overall checkout system was provided with eight modes of operation for system flexibility, ease of operation and maintenance. Modes of operation provided include: stop test, automatic run until a no-go occurs, one test at-a-time, line by line, test number locate by dialing, manual program, high-speed wind and rewind. Built into measurement section is also a reread mode allowing operator to re-examine the voltage in question as often as required.



FRONT COMPARTMENT of mobile test set stores components in readily-accessible locations. Large rectangular unit in upper-left rack is cockpit subcontroller. Below subcontroller are seen four intercom control sets. Three surface-motion transducer assemblies are seen mounted at right. Cabling is nested on both doors.

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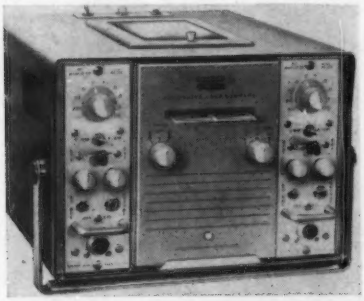
Aerospace Products at WESCON

More WESCON Products on Page 67, "Parts and Components"

Portable Recorder

Meterite 40 mm amplitude two-channel rectilinear recording system features interchangeable plug-in pre-amplifiers. Two models are



available: BSA-250 using ink writing, and BSA-260 for electric writing in addition to ink. Model BSA-250 consists of a basic system assembly and two interchangeable plug-in pre-amplifiers: Low, medium, and high gain DC; carrier; or servo types. The basic system assembly comprises a chart drive with six electric speeds (.5, 2, 5, 20, 50, and 200 mm/sec), two oscillograph units (one with manual 60 cycle signal event marker), and two transistorized compensated driver amplifiers. Power requirements are 105-125 volts, 60 c, 60 w.—MASSA Div., Cohu Electronics, Inc. Booth 557

Circle 50 on postcard for more data

Air Data System

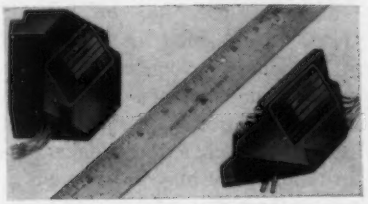
A central air data system to supply flight data to major F-104G

systems including the auto-pilot, in-range computer, fire control computer, and landing gear warning, uses modular construction. The system consists of a transducer package and a total temperature sensor. The computer package uses an electromechanical anolog mechanization to compute performance parameters.—The Garrett Corp., AiResearch Mfg. Co. Booth 2056.

Circle 51 on postcard for more data

Temperature Control

One control box in two multi-faced parts has been designed for a missile application. It has form-fitting design for space limitations and close-operating tolerance. The box is smaller than a four-inch cube and controls temperature to less



than ±0.03°F. One half of box is a power amplifier and the other half a pre-amplifier connected to a miniature sensing element. A transistorized circuit is used.—Barber-Colman Co. Booth 2301.

Circle 52 on postcard for more data

Epoxy Laminates

Textolite epoxy laminates, Grade 11574, a paper-base type, and Grade 11559, a G-11 high-temperature type, are displayed. Typical applications are printed circuits, punched or machined parts, tube sockets, and terminal strips. Textolite 11559 is said to be the only self-extinguishing G-11 (high-temperature) electrical laminate. It also offers uniformly high bond-strength, and almost negligible water absorption. These properties make the laminate useful for computer circuits and military electronic applications.—General Electric Co. Booth 211B

Circle 53 on postcard for more data

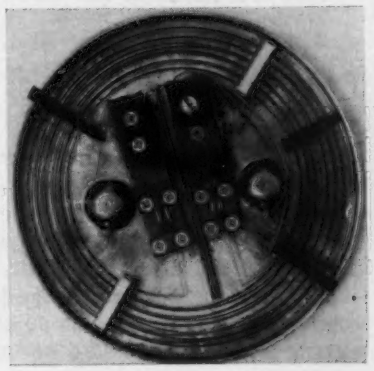
Brake-Clutch

Known as Autotronics Pancake PMC-8, this unit is a brake energize to clutch designed for close coupled applications where high performance, fast response, reliability and low inertia are desired. Unit length from servo flange to end of cap is 0.500-in. Servo mounting has one-inch diam. Power consummation is 4.5 w; response is eight milli seconds. Pancake units feature impregnated and encapsulated coils, and are vibration, temperature and attitude proof per Mil-E-5272A.—Autotronics Inc. Booth 2619

Circle 54 on postcard for more data

Sonic Delay

A 970 microsecond wire sonic delay 5½ in. diam, weighing three ounces, and ¼ in. thick, has a digital storage rate of one microsecond. This delay line uses piezoelectric transducers for input to provide a lower insertion loss and



WESCON Products

yield a larger dynamic range of input voltage levels.—General Electric Co., Heavy Military Electronics Dept. Booth 2126.

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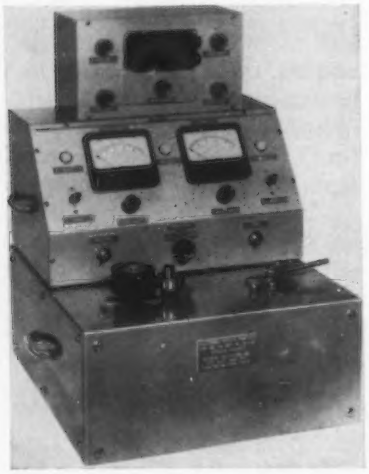
Bearing Analyzer

Model BA-20 bearing analyzer designed to check the quality of anti - friction bearings is being shown. The instrument identifies unserviceable bearings, visually and

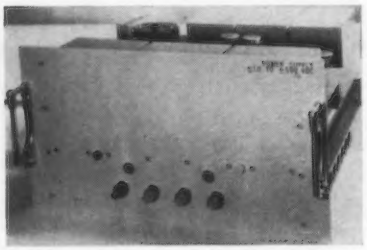


audibly. Rejection is indicated by a red light. Complete check of balls, rollers and all raceways takes 30 sec. Bearings from the smallest instrument sizes up to 10 in. OD can be checked.—Bearing Inspection, Inc. Booth 105

Circle 56 on postcard for more data

Programmable Power Supplies

Recently introduced are power supplies for precision test use—models PS-32, 33 and 34. These transistorized units are designed to furnish well regulated, highly accurate voltages from a programmed source. Voltage ranges of the three models are, for the PS-32-6 to 36 vdc in 0.1 v. steps at 30 amps; the PS-33-1 to 500 vdc in 1 v. steps at 1 amp and the PS-34-0 to 99.9 vdc in 0.1 steps at 1.5 amps. The programmable section of each model



includes a binary-coded, decimal control system which establishes in the power supply any voltage falling within its range.—Southwestern Industrial Electronics Co. Booth 530

Circle 57 on postcard for more data

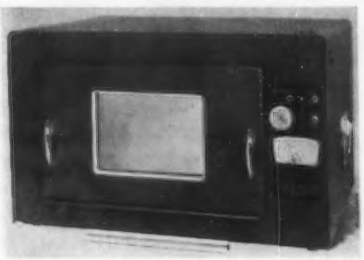
Fluid-Filled Rate Gyros

Measuring less than one in. in diam and 2.45 in. in length, these units are of two basic types: A2016-01A has a simple viscous shear type damper providing a relatively constant damping ratio; A2016-01B is equipped with a mechanism compensating for fluid viscosity within ±20 per cent from −55°C to −85°C without use of heaters. Gyros are designed for application in autopilots, telemetering instruments, radar antenna stabilization and fire control systems, and solid fuel missiles demanding rapid warm-up time. They may be supplied in two or three-axis rate sensing packages—Kearfott Div., General Precision Inc. Booth 626

Circle 58 on postcard for more data

Crystal Oscillator

DFO-12 is available at any frequency from 3 mc to 100 mc in a subminiature package of one cubic inch. Circuit is completely encapsulated with Silastic RTV 501 for operation in extreme vibration and shock environments. Silicon transistorized unit provides a frequency stability of 0.005 per cent from −55°C to +90°C. Output power 0.1 mw minimum. Load impedance 50 ohms (as high as 600 ohms available.) The supply voltage as specified to 30 v.—Delta-f, Inc. Booth 2064



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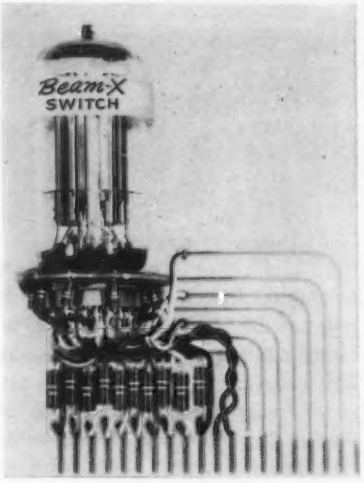
Distributor Module

Model D-9000 module is for use in sequencing, sampling, multiplexing and similar systems. Heart



of the unit is the new BEAM-X Switch, Type BX-1000, a ten-position electron distributor whose ability to control an electron beam to any one of ten outputs makes it essentially ten devices in one. Distributor is flexible electrical characteristics allow its use in systems operating from 60 to 300 V. It is capable of accepting serial input pulses at frequencies to 100 Kc from commercially available plug-in modules.—Burroughs Corp., Electronic Tube Div. Booth 2136

Circle 60 on postcard for more data

Telemetering Minifilters

These units are for use with transistors (input and output impedance 10,000 ohms), and are ideally suited to printed circuits. No mounting facilities are employed, since the straight pin terminals adequately support these light weight

units. A complete set of 18 filters occupies about 9½ in., and weighs approximately 14 oz. Corresponding discriminator units to specific circuit needs are available on production order . . . approximately same size. — United Transformer Corp. Booth 430

Circle 61 on postcard for more data

Binary-To-Decimal Converter

Model 100TBD is a compact transistorized converter which permits direct decimal readout of up to 13 bits of binary coded information. It is designed to operate as a readout for encoders or shaft position digitizers similar to the Norden ADC-13-BNRY and the Librascope Model 713 (with BL513a logic). It will, however, convert and display decimally up to 13-bit binary coded information from a source of voltages or contact closures. Can be installed in a standard 19 x 7 in. panel for rack mounting. It includes power supply for operation from 115 v 60 cps line. Power requirement is about 50 w.—Erie-Pacific Div., Erie Resistor Corp. Booth 547

Circle 62 on postcard for more data

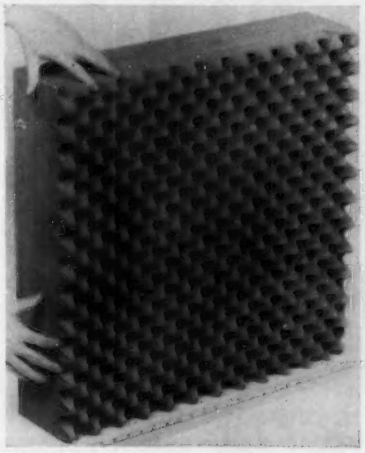
Photoelectric Sensor

Photoelectric sensing device automatically controls bowls feed attachment. Feeder is used in conjunction with axial lead component packaging and testing machines. It permits fully automatic feeding of resistors, diodes and capacitors into high speed straightening, testing, orienting, taping and reeling machine. The photoelectric circuit signals the bowl feeding attachment when level of components stacked in the input chute of the machine has dropped below a minimum level.—Universal Instruments Corp. Booth 330

Circle 63 on postcard for more data

Microwave Absorber

Eccosorb CV is a series of broadband absorbers for free space applications which are 40 db down



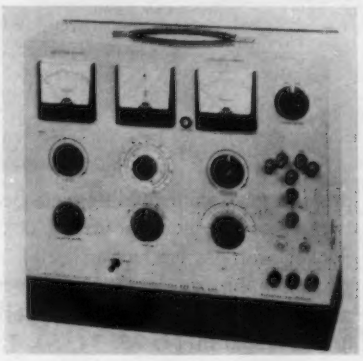
(0.01 per cent reflection) over their operating frequency range. It is used in the critical microwave darkroom applications.

Material is made from light weight artificial dielectric loaded flexible foam; front surface is rippled and light in color for good light reflection. Sheet size is 24 x 24 in.—Emerson & Cuming, Inc. Booth 120

Circle 64 on postcard for more data

Portable Tester For Transistors

Power transistor measurements to 30 amp collector current and 300 breakdown test potentials are now possible with Type 300 test set. Direct meter readings or large signal current gain (H_{FE}) and collector characteristics I_{CBO}, I_{CER}, BV_{CEO}, and BV_{CBO} can be made



rapidly, and accurately under conditions typical of their actual applications. Set is adapted to quality control Go No-Go checking of H_{FE}, with preset acceptance values. Sturdily packaged in a single metal case with carrier handle, set measures 17 x 16 x 7 in.—Luscombe Engineering Co. Booth 2832

Circle 65 on postcard for more data

Variable Transformers

With a continuously-adjustable voltage from a-c power lines are Powerstat transformers available in several series for high frequency applications. Designed for single and three phase, 400/800 c operation, manual and motor-driven air-cooled models are offered for 28, 120, 240 and 480 v service in ratings from 56 VA to 8.7 kva. Units can operate at –55°C to +40°C at full rated load; up to 50,000 ft; to 95 per cent relative humidity; vibration, per MIL-T-17113, OQM-151-A, etc.—The Superior Electric Co. Booth 1067

Circle 66 on postcard for more data

High Temp Laminate

Dilecto laminated plastic for applications requiring exceptional heat resistance, is announced. Made by impregnating graphite fabric with a heat-resistant phenolic resin, the material is known as N-104-84-2. Sample quantities are available to companies having a "DX-A2" Ballistic Missile Program priority. Samples are available in laminated six-inch squares up to ½ in. thick; or in three-inch diam cylindrical moldings, made from macerated impregnated fabric, in depths up to 2 in. In laboratory ablation tests, at 5000°F, material displayed a burn-through rate of less than 0.0005-in./sec.—Continental Diamond Fibre Corp. Booth 212

Circle 67 on postcard for more data

Diffused Silicon Diodes

A line of diffused silicon diodes are offered. Two major classifications include: fast recovery types

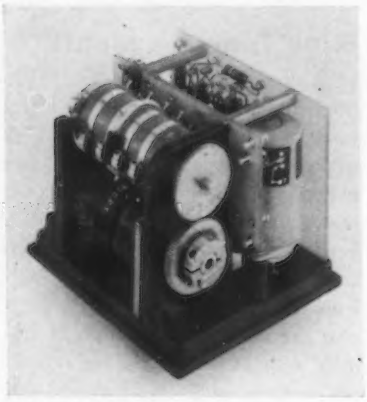
WESCON Products

and high conductance types designed for airborne and industrial computers. Typical applications include switching, pulse, flip-flop, modulator, demodulator, discriminator, clamping, gating and detector circuits. The fast recovery types provide 400,000 ohms (Zrec) in 1.0 usec (I_F = 30 mA, E_R = —35V, R_L = 2K ohms). High conductance types feature a maximum average forward current of 100 mA at 1.1 v. —CBS Electronics, div of Columbia Broadcasting System. Booth 2524

Circle 68 on postcard for more data

Velocity Multiplier

Model VM 1019 velocity multiplier provides a potentiometer shaft position determined by the level of

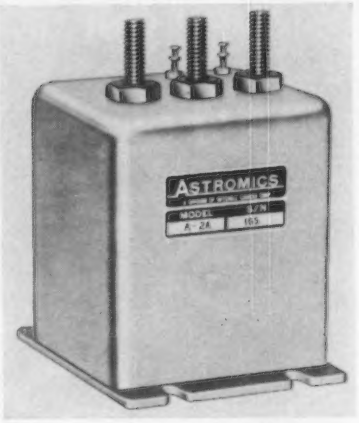


a d-c signal input. It incorporates a vibrating reed chopper, a subminiature vacuum tube amplifier, a precision two-phase servo motor with integral gearhead (ratio: 70 to 1) and a stack of four potentiometers. Characteristics include—Power input—115 volts, 400 cps, 6.3. volts, 400 cps, 200 V, DC, unregulated; 200 V, DC, regulated for feedback circuit, 10 ma max.—Instrument Div, American Electronics, Inc. Booth 2349

Circle 69 on postcard for more data

Latching Relay

Designated as A-2A, this relay mechanically locks in either open or

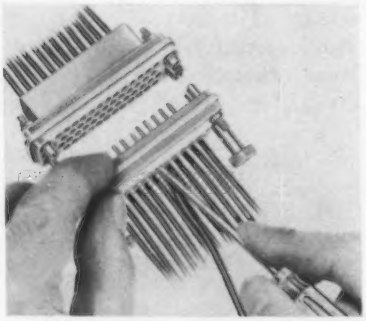


closed position, and requires a new command pulse to be re-activiated. It functions on the plug-in principle, assuring positive contact under extreme conditions, and permits a load up to 20 amps at 26.5 v dc (resistive). Relay operates by a single solenoid with a double plunger. Both plungers are connected to a ratchet mechanism. Ratchet and plungers, make up a balanced assembly against shock and vibration. Astromics Div., Mitchell Camera Corp. Booth 838A

Circle 70 on postcard for more data

Connectors

Miniature rectangular connectors have crimp termination removable contacts. An extra-wide, three-tine spring clutch on pin and socket

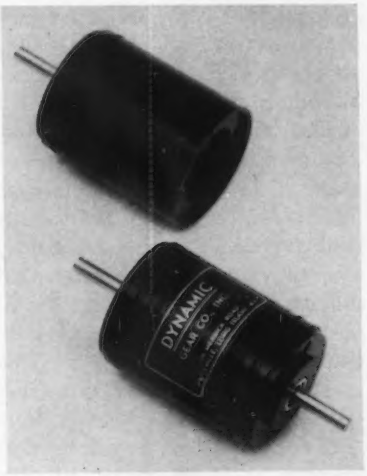


provide maximum holding area between contact and molded block. Socket and pin contact material is phosphor bronze, gold plate over silver plate. Series 2500 connectors are available in 14, 26, 34, 50, 75 and 102-contact sizes with removable contacts for #14 to #24 AWG wire. Contacts are supplied separately. The Crimp termination eliminates all soldering. — Continental Connector Corp. Booth 855

Circle 71 on postcard for more data

Speed Reducers & Gearheads

New line of speed reducers and gearheads features whole - number ratios. This eliminates need for the design engineer to make extensive, time-consuming calculations. Featuring postless type construction,



these units offer ratios accurate to within 0.5 per cent. They are for mounting on standard Buord MK 14 servomotors. Speed reducers and center-shaft gearheads are available in over 190 stock ratios—from 7:1 to 5950:1. One unit is also available in a ratio of 5¼:1. Units are either opposite or direct rotation and lubricated for life (–55°C t1 100°C) and measure 1.420 in. overall.—Dynamic Gear Co. Booth 438

Circle 72 on postcard for more data

Static Converter

Model 3078 converter is designed for continuous operation in missile checkout systems, fire-control systems, computer power, general instrumentation etc. Input voltage is 115 vac ±10, single phase; frequency 60 cps.—Varo Mfg. Co. Booth 2332

Circle 73 on postcard for more data

TA "King-Size" Instrument Cases 4 PAGES

TA Standard Instrument Cases 20 PAGES

Learn how TA's new predesigned Instrument Cases solve *your* equipment housing problems.

SEND FOR YOUR FREE COPIES!

THESE EXCLUSIVE FEATURES—STANDARD WITH TA—SAVE YOU TIME AND COST

1. Predesigned panel-layouts for perfect fit.
2. Large selection of standard sizes and styles.
3. Wide choice of standard handles, access doors, panels, and other accessories.
4. All standard Cases include panel gaskets.
5. All Cases protected by air relief valves.
6. Available in depths from 2½ to 18 inches.
7. Fast delivery (prototypes in 4 weeks).
8. No tooling charges on standards.
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10. Reinforced aluminum construction.
11. TA Cases are color matched to, and integrated with, the instruments they are to contain.

INSTRUMENT MANUFACTURERS: If you make portable instruments or equipment, you can't afford *not* to investigate the TA line.

TA Cases come in a diversity of standard lid sizes, and are sold at proprietary prices. During assembly the depth can be cut to your exact specifications. Or, if you like, TA will furnish you free vellums and templates so you can save yourself money by designing your product to fit one of the many standard sizes.

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TWX 9863 Glendale, Calif. • WUX CAT Los Angeles, Calif.

Circle 21 on Inquiry Card

FOCUS ON MYSTIK BRAND® TAPES

Take your problems to tape headquarters . . . Mystik. Here, in our full line of self-stik Mystik Brand Tapes and specialties, you'll find *color* tapes that code, identify, decorate . . . *waterproof* tapes that seal and protect . . . *super strength* tapes that perform heavy duty banding operations . . . *hi-low temperature* tapes that withstand the most severe conditions. For full information, write:

MYSTIK® SELF-STIK

Mystik Adhesive Products, Inc.
2635 N. Kildare Ave., Chicago 39

Circle 22 on Inquiry Card

Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster® Patented, No. 2,523,936

by IDEAL

IDEAL INDUSTRIES, Inc.
1380-H Park Avenue, Sycamore, Ill.

Gentlemen: Please send catalog information on IDEAL's New "Custom Stripmaster."

Name_____

Company_____

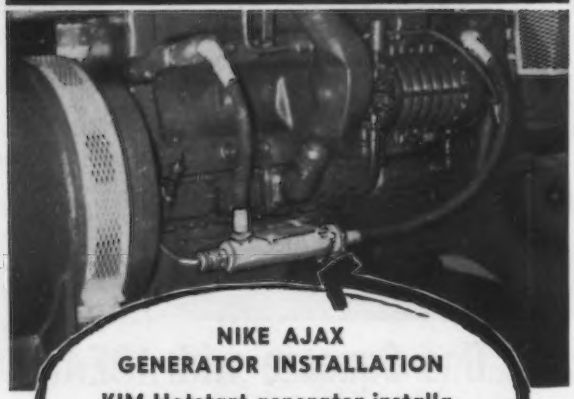
Address_____

City_____ Zone____ State_____

Circle 23 on Inquiry Card

Instant Starts—Instant Peak Performance from Power Units, Crash Trucks, Service Equipment with . . .

KIM HOTSTART



NIKE AJAX GENERATOR INSTALLATION

KIM Hotstart generator installation keeps missile defense on all-weather alert.

ELECTRIC PRE-HEATER FITS ALL INTERNAL-COMBUSTION LIQUID COOLED ENGINES

KIM Hotstarts installed on tractors, crash trucks and service equipment give you ready, warmed-up engines . . . instant starts. Power units operate at peak performance immediately and *under full load*. Service Equipment and crash trucks are ready to roll when minutes mean dollars . . . or lives. Additional time is saved because equipment may be stationed where used most, regardless of weather.

KIM Hotstarts are easy to install, easy to use. Simply plug installed Hotstart into electric circuit. Cold water is drawn from the engine and percolator-like action circulates hot water. One-way valve allows normal circulation when engine is running. Safe, explosion-proof cap permits use near fuels.

Lengthen the life of your gas and diesel driven equipment by installing KIM Hotstarts. Save with less down-time, lower maintenance costs, instant equipment availability at peak operating performance.

Write today for free literature or see your automotive dealer.

KIM Hotstarts have astronomical approved Part Numbers.

KIM Hotstart

KIM HOTSTART MANUFACTURING CO.
West 917 Broadway Avenue P.O. Box 42 Spokane 10, Washington

Circle 42 on Inquiry Card

METROPOLITAN MIAMI MARKETS

THE LABOR MARKET

The Last Unlimited Source of Skilled and Professional Labor. A great percentage of Americans want to live in South Florida . . . this area, therefore, has an immediate pool of skilled labor in every category.

THE SALES MARKET

Metropolitan Miami is the Focal Point of Four Great Markets: Dade County, the Gold Coast, the Southern U.S. Market and the Caribbean—Latin America.

Send for **30-SECTION ECONOMIC SURVEY OF METROPOLITAN MIAMI**

This important survey will be mailed to you free of charge—in strictest confidence—if you write, on your letterhead, to the address listed below.

Write: R. Richard Welsh, Director

DADE COUNTY DEVELOPMENT DEPARTMENT
345 NORTHEAST SECOND AVENUE • MIAMI, FLORIDA

An agency of the Metropolitan Miami Government

Circle 39 on Inquiry Card

PANDUCT FITTINGS*

MAKE THE BEST WIRING METHOD BETTER . . .

* SNAP-IN CORNER, TEE AND STRAIGHT-THRU FITTINGS.

SEE PANDUIT WIRING COMPONENTS—BOOTH 346
WESCON SHOW
LOS ANGELES, CALIFORNIA

PANDUIT CORP. 14461 WAVERLY AVENUE Dept. A, MIDLOTHIAN, ILL.

Circle 44 on Inquiry Card

Men on the Move

WILLIAM T. CALDWELL, named director of the new marketing department at Amelco, Inc.

JERRY D. MAXA, appointed General Sales Manager of Koehler Aircraft Products.

DR. SOLOMON L. MILLER, named head of the research section of the research and development department, Rheem Semiconductor Corp.

HARRY K. COLLINS, appointed executive vice-president and general manager of the Paraglas Div., Air Logistics, Inc.

THOMAS L. K. SMULL, appointed director of NASA's Office of Research Grants and Contracts.

CURTIS M. LEE has joined Wyle Manufacturing Corp. as chief engineer.

B. F. COFFMAN, JR., appointed manager, Hybrid Rocket Engine Projects, the Aerojet—General Corp.

MOSES SHAPIRO, elected president and MONTE COHEN elected vice chairman of the board, at General Instrument Corp.

CHARLES H. KLEIN, elected director of Twin Coach Co.

H. FRENCH HARRIS, appointed manager of the Discoverer and Samos satellite projects at the Western Development Laboratories of Philco. Corp.

FRANK E. NAMROL, appointed chief engineer at Piasecki Aircraft Corp.

MAJ. GEN. EUGENE P. MUSSETT (USAF, ret.), named site integration manager for the Martin Co. at the Titan ICBM base at Ellsworth Air Force Base, Rapid City, S. D.

CLAUDE A. BROSTERHOUS has joined Aeronutronic Div. of Ford Motor Co. as assistant manager of systems test and prototype fabrication for tactical weapon systems operations.

DR. D. M. ALLISON, appointed technical assistant to the vice president of engineering and research at The Bendix Corp.

LEONARD E. STILWILL, named manager of sales at the Arizona Div. of Goodyear Aircraft Corp.

JAMES E. HEYWOOD has joined Ford Motor Company's Aeronutronic Division as assistant general operations manager of Computer Operations.

R. MERRILL BUSHONG, named director of the Advanced Materials Project conducting graphite research at National Carbon Co.

FRANCIS X. BUSCHMAN, appointed director of research, development and engineering of Hitemp Wires, Inc.

JAMES H. VAUGHAN, appointed director of defense products of American Car and Foundry Div. of ACF Industries.

DR. H. IGOR ANSOFF, named vice president, plans and programs, for Lockheed Electronics Co. DR. EDWARD M. PRITCHARD, named director of engineering for the Military Systems-Stavid Div., Lockheed Electronics.

DR. WILLIAM L. WHITSON elected a vice president, The Martin Co.

ROBERT R. WILLIAMSON, appointed director of military sales for Librascope Div.—General Precision, Inc.

DR. JOHN A. MAURO, appointed consulting optics engineer, at the Ordnance Dept., General Electric Co.

DR. ROBERT E. WALL, JR., has joined Electro-Optical Systems, Inc., as a senior scientist in the Energy Research Div.

JAMES N. EDWARDS and ALEX MARCO, appointed members of the technical staff, Space Electronics Corp.

HAROLD W. LEBOEUF, named manager of manufacturing of General Electric's Silicone Products Dept. R. E. HORNER, named manager-marketing for the Light Military Electronics Dept.

RONALD E. CUNNINGHAM, appointed director of sales for Anadite, Inc.

JULES KRAVETZ, named director of government relations for Aerolab Development Co.

DR. MILES C. LEVERETT, manager-development laboratories for the General Electric Aircraft Nuclear Propulsion Department, named president of the American Nuclear Society.

EDWARD F. CANFIELD, appointed marketing manager for the Philco Corp. Research Div.

BEN W. BADENOCH, elected a vice president of Vickers Inc.

R. Merrill Bushong
National Carbon

Francis X. Buschman
Hitemp Wires

James H. Vaughan
ACF

Dr. H. Igor Ansoff
Lockheed Electronics

Dr. William L. Whitson
Martin

Robert R. Williamson
Librascope

Harold W. LeBoeuf
General Electric

Jules Kravetz
Ryan Aerolab

Edward F. Canfield
Philco

Ben W. Badenoch
Vickers

ENGINEERS

SITE ACTIVATION

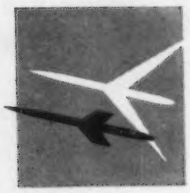
We're rolling up our sleeves for the next important step of activating bases throughout the United States. Design or liaison engineers with B.S. in M.E. or E.E. and experience in electrical or mechanical systems are required for liaison work at missile launching complexes, or design support work on launch control equipment, propulsion systems, automatic programming and missile checkout equipment operations.

Assignments are at Warren Air Force Base, Cheyenne, Wyoming; Offutt Air Force Base, Omaha, Nebraska; Fairchild Air Force Base, Spokane, Washington; and in San Diego.

Please send complete resume to Mr. R. Merwin, Engineering Personnel Administrator, Dept. 130-90, 5540 Kearny Villa Road, San Diego, Calif.

CONVAIR/ASTRONAUTICS
CONVAIR DIVISION OF
GENERAL DYNAMICS
Circle 202 on Inquiry Card

Worth Asking For



Human Factors
Bibliography on human factors in space flight; compiled for article "Man-Machine Space Complex" in July issue, Aircraft & Missiles.—*Chilton Co.*
Circle 74 on postcard for more data

Materials Research
Brochure illustrates instrument laboratory: microscopy, spectrography.—*Ernest F. Fullam Inc.*
Circle 75 on postcard for more data

Starting System
Folder describes design and operating features of the Sundstrand Starter-Drive for aircraft.—*Sundstrand Aviation.*
Circle 76 on postcard for more data

Cats
Uses of Caterpillar diesel engines.—*Caterpillar Tractor Co.*
Circle 77 on postcard for more data

Bend-Amatic
Spec sheet on component dispenser.—*Schmit Engineering Co.*
Circle 78 on postcard for more data

Automatic Lathe
Circular describes 3E-15 automatic turret lathe.—*Pratt & Whitney.*
Circle 79 on postcard for more data

InFab
Brochure shows refractory metal fabrication, with outline of processes.—*Refractomet Div., Universal-Cyclops Steel Corp.*
Circle 80 on postcard for more data

Pressure Vessels and Tubing
Folder describes firm's tubes and vessels used in ground support and in missiles.—*U. S. Steel Corp.*
Circle 81 on postcard for more data

Missile Launcher Fluid
Eight-page data booklet on properties and handling of Ucon Hydraulic Fluid M-1 developed for Titan hard sites.—*Union Carbide Chemicals Co.*
Circle 82 on postcard for more data

Life Support
Firm's life support system research summarized.—*Missile and Space Vehicle Department, General Electric.*
Circle 83 on postcard for more data

Particle Counter
Brochure on monitor for clean rooms.—*Royco Instruments.*
Circle 84 on postcard for more data

Magnesium
Brochure on magnesium applications in electronics.—*The Dow Metal Products Co.*
Circle 85 on postcard for more data

Extrusion Design
Comprehensive brochure on custom extrusion.—*Anchor Plastics Co.*
Circle 86 on postcard for more data

Environmental Facilities
Quality control environmental test labs described.—*Missile and Space Vehicle Dept., General Electric Co.*
Circle 87 on postcard for more data

Lithium: Alloys
Bibliography of 316 articles about uses of lithium in non-ferrous alloys.—*Foote Mineral Co.*
Circle 88 on postcard for more data

Piezoelectricity
Folder contains basic principles of "pressure" electricity.—*U. S. Sonics Corp.*
Circle 89 on postcard for more data

Accelerometers
Description, specs, design drawings of liquid damped and regular angular accelerometer systems.—*Donner Scientific Co.*
Circle 90 on postcard for more data

Aircraft Fueling
Bulletins give history, use of Pulsco Bellows Shock Trap for jet fueling.—*Pulsation Controls Corp.*
Circle 91 on postcard for more data

Ground Checkout
Brochure, "Automatic Electronic Checkout Equipment."—*Packard Bell Electronics*
Circle 92 on postcard for more data

Mercury Ground Support
Brief report on Mercury tracking network.—*Burns and Roe Inc.*
Circle 93 on postcard for more data

J 85
Bulletin GED-4096 reports on progress of J 85 turbojet.—*General Electric Co.*
Circle 94 on postcard for more data

Titanium
Bulletin, "Titanium Facts," includes charts cataloging various types of titanium and titanium alloys with technical data.—*Nooter Corp.*
Circle 95 on postcard for more data

Elastomers
Property tables of elastomer types.—*Lord Manufacturing Co.*
Circle 96 on postcard for more data

Fiberglass

Brief description of molded compressible fiberglass.—*Enfab.*

Circle 97 on postcard for more data

Computerese

Pocket "dictionary" of computer jargon.—*Minneapolis-Honeywell Regulator Co.*

Circle 98 on postcard for more data

Miniature Nuts

Reference guide on line of miniature locknuts and gang channel.—*Kaylock Div., Kaynar Mfg. Co.*

Circle 99 on postcard for more data

Filters

Bulletin on filter elements for jet fuel.—*Filters Inc.*

Circle 100 on postcard for more data

Atomic Uses of X-Rays

Folder is reprint of an article that appeared in a national trade publication. *Philips Electronic Instruments.*

Circle 101 on postcard for more data

Tantalum Capacitors

Data on tantalum electrolytic capacitors for elevated temperature applications. *Fansteel Metallurgical Corp.*

Circle 102 on postcard for more data

Joining Manual

Survey of aluminum welding, brazing and soldering. *All-State Welding Alloys Co.*

Circle 103 on postcard for more data

Lubricant

Four-page bulletin describes industrial application of Molykote Type G, a grease-consistency lubricant. *The Alpha-Molykote Corp.*

Circle 104 on postcard for more data

Electronic Tubes

Microwave tube operations described. *Sperry Electronic Tube Div.*

Circle 105 on postcard for more data

Plant Location

Folder "At Your Command" outlines group's plant location services for industry. *Niagara Mohawk Power Corp.*

Circle 106 on postcard for more data

Structural Adhesives

Reference folder: advantages, uses, concepts of structural adhesives. *Minnesota Mining and Manufacturing Co.*

Circle 107 on postcard for more data

New Books

AIRCRAFT ELECTRICAL ENGINEERING. Edited by G. G. Wakefield. MacMillan, 1959, 349 pp., $10.00. This book is based on a series of lectures given at the Imperial College of Science and Technology, London, in 1954; it is a textbook published under the authority of The Royal Aeronautical Society. Subject matter treated includes: environmental conditions, high-altitude brush wear, vibration problems, switchgear, batteries, power systems; cooling methods and related problems are discussed with special emphasis.

PROPERTY MEASUREMENTS AT HIGH TEMPERATURES—Factors affecting and methods of measuring material properties at temperatures above 1400°C (2550°F). By W. D. Kingery. Wiley, 1959, 416 pp., $16.50. This book is intended primarily as an introduction to the subject, based on the assumption that the reader has completed all or most of the undergraduate courses in science or engineering. Each chapter is prefaced by introductory material as a refresher on the topic to be discussed. Numerous references, grouped categorically, are furnished at the end of chapters. Methods of measurement are treated in detail, with special emphasis on material description. Illustrations are provided throughout to describe the apparatus involved in various measurement techniques.

NOMOGRAPHY. By Alexander S. Levens. Wiley (Second Edition), 1959, 296 pp., $8.50. This is a revised and greatly expanded version of an earlier work by the same name. Proponents of graphical representation will find here the basic tools for the construction of time-saving nomograms applicable to their particular field of endeavor. Chapters are included on circular nomograms, projective transformations and the relationship between concurrency (Cartesian) and alignment nomograms. An extensive appendix gives typical examples of nomograms applied to engineering, science, business, food technology, medicine, etc.

FLIGHT TEST ENGINEERS

Versatile, practical-minded engineers with a record of accomplishment in the missile, aircraft or related fields will now qualify for a flight test position at Convair/Astronautics—creators and testers of the mighty Atlas ICBM. Positions must be filled immediately at various locations from Cape Canaveral, Florida, to Vandenberg AFB near Santa Maria, California. Openings exist in: Propulsion • Hydraulics • Pneumatics • Propellant Transfer Systems • Missile Structures • Autopilot and Guidance • Launch Control Systems • Electrical Power • R.F. Systems • Telemetering • Landlines • Ground Support Equipment • Closed Loop TV Systems • Data Analysis.

Write now to Mr. R. B. Merwin, Engineering Personnel Administrator, Department 130-90, 5543 Kearny Villa Road, San Diego, California.

CONVAIR/ASTRONAUTICS
CONVAIR DIVISION OF
GENERAL DYNAMICS

Circle 203 on Inquiry Card

New Materials

Tantalum Gaskets

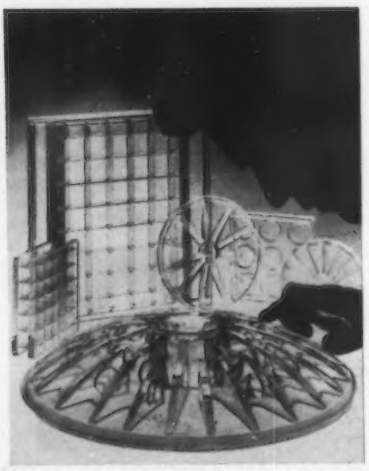
Tantalum shielded gaskets are being field tested in applications beyond the temperature range of Teflon. They can be used in highly

corrosive environments at temperatures to 700°F and pressures to 1000 psi. New gaskets were designed for use primarily with tantalum-lined vessels which operate in excess of 500°F. The material is attacked by hydrofluoric acid and alkaline solutions above pH of 8. It is susceptible to corrosion in fuming sulphuric acid, chlorosulfonic acid and SO_3.—The Pfaudler Co.

Circle 108 on postcard for more data

Sandwiched Mirrors

Unusual sandwich-type construction is used in lightweight telescope disks. They are intended for



use in missiles, satellites and aircraft. The mirrors consist of two plates of fused silica, held apart by ribs or tubes of the same high purity purity material. Weight-saving construction is aimed at making the mirrors light enough for compact telescopes needed in outer space photography.—Corning Glass Works.

Circle 109 on postcard for more data

Insulates Yet Conducts

Precision cylinders of beryllium oxide ceramic are now available. The material is an excellent electrical insulator like most ceramics, but it conducts heat like a metal.

Applications for the material are in electronics, nuclear reactors, and such missile components as nose cones and radar "windows."—National Beryllia Corp.

Circle 110 on postcard for more data

Antioxidant Spray

Precoating method prevents oxidation and material loss during thermal-treating of exotic metals. Copper or aluminum is sprayed on. This produces an oxide coat. The precoat forms a lubricant for subsequent forming. Coating is applicable to any metal to which aluminum or copper is non-alloyable. During the thermal treating the organic binder is burned out. Oxide can be removed by NaOH dip.—Chance Vought.

Circle 111 on postcard for more data

"Stable" Explosive

Guanidinium perchlorate, a compound with applications as an explosive or monopropellant, has been announced. The compound is thermally stable to 350°C.—National Northern Div. American Potash & Chem. Corp.

Circle 112 on postcard for more data

Fastest Film

Royal-X Pan Recording Film is said to be fastest black-and-white motion picture film available. It is the standard recording material for the Smithsonian satellite-tracking program. Suggested daylight exposure index is 1600. The film is available in 16 mm, 35 mm, and 70 mm widths, and in various lengths and perforations.—Eastman Kodak Co.

Circle 113 on postcard for more data

Self-Coating Ceramic

Experimental ceramic graphite-base material spontaneously forms its own protective coating against heat and oxidation. The maximum tension and compression capability of the material is about double that of standard graphite at room temperature. It also has a strength ad-

vantage at temperatures above 3000°F. Typical composition consists by weight of 50 per cent graphite, 24 per cent molybdenum disilicide and 25 per cent titanium boride plus minor ingredients to promote bonding. The protective layer develops at 2200°F.—Boeing Airplane Co.

Circle 114 on postcard for more data

Single Metal-Crystals

New class of metals offers extreme resistance to heat and the ability to be worked by standard machining methods. Called large single crystals, the materials preserve the standard melting points of the refractory metals (2947°F for vanadium to 5582°F for tungsten), yet give ease of fabrication. Crystals have import in electronics and astronautics, where hot temperatures, wear, and corrosion are design considerations. A bolt made of this material can be threaded at room temperature without cracking.—Linde Co.

Circle 115 on postcard for more data

Self-Lubricating Steel

Dargraph, a premium quality oil-hardening graphite tool steel, is machinable because 1/3 of the carbon is uniformly distributed as free graphite to increase anti-friction properties. Material is an AISI-SAE Type 06 steel. Its percentage composition is: C 1.45, Mn 0.80, Si 1.15, Cr 0.20, Mo 0.25, P and S 0.03 max. Heat treating is safe because Dargraph is nondeforming and has a broad hardening range: 1475-1550°F. Oil quenching will give 63-66 Rc; cooling in still air about 30-35 Rc.—Darwin & Milner Inc.

Circle 116 on postcard for more data

Space Age Steel

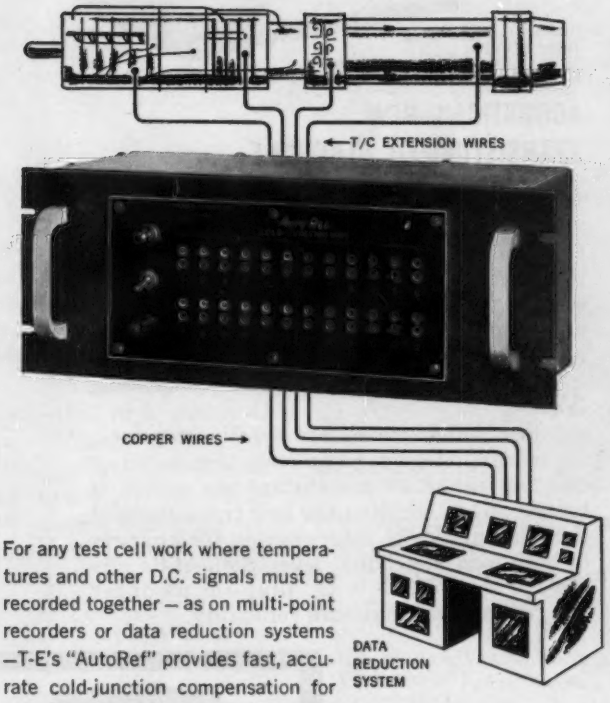
MX-2, a cobalt-modified low-alloy steel, is designed to meet three basic requirements in solid propellant missiles: improved reliability, weight reduction, and greater strength for use with higher impulse propellants.—Scaife Co.

Circle 117 on postcard for more data

T-E's *AUTOREF* Provides

Cold Junction Compensation For Many Thermocouples

Ideal For Data Reduction Systems



For any test cell work where temperatures and other D.C. signals must be recorded together – as on multi-point recorders or data reduction systems –T-E's "AutoRef" provides fast, accurate cold-junction compensation for the thermocouple circuits. In one, compact unit it gives you constant, pre-determined, cold-junction reference for many thermocouples – actually up to several hundred. Typically, cold-junction temperatures can be controlled to within ±1°F. over a wide range of ambient temperatures.

Besides its accuracy, the "AutoRef" offers tremendous convenience – saving both time and effort. Designed for panel rack mounting, it can be introduced anywhere in the thermocouple circuit – no matter where thermocouples and instruments are located. Whenever temperatures, pressures, flow-rates and other electrical and mechanical conditions are being recorded simultaneously, the "AutoRef" does away with the need for maintaining ice baths or making laborious correlations. It is available for all standard thermocouple calibrations.

Write for Bulletin 81-1

Thermo Electric Co., Inc.
SADDLE BROOK, NEW JERSEY
In Canada — THERMO ELECTRIC (Canada) Ltd., Brampton, Ontario

ANNOUNCING!

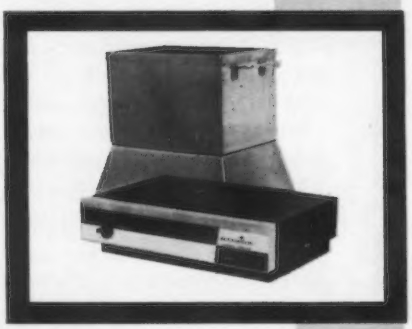
new speed,
new efficiency in ultrasonic cleaning

ACOUSTICA'S NEW TRANSISTORIZED 20-KC LINE

Ultrasonic cleaning takes on a new dimension with Acoustica's fully transistorized electronic generators for use with "Multipower" transducers and tanks. A completely different operating principle eliminates all tuning, adjustments and meter readings and obtains maximum power from all transducers, even when several are used in a single cleaning tank.

Speed and efficiency are greatly increased, for warm up time is completely eliminated... cleaning can start the instant the switch is turned on! In addition, the new transistorized unit automatically compensates for changes in both load and liquid level. Solid-state circuitry, combined with plug-in modular design, assures maximum reliability.

The new fully transistorized generators can be used either in special systems or with Acoustica integral tank-and-transducer combinations. Learn how this new dimension in Ultrasonic Cleaning can cut both production cleaning costs and rejects.



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WRITE TODAY FOR COMPLETE OPERATING SPECIFICATIONS.

acoustica

ACOUSTICA ASSOCIATES, INC.
10400 Aviation Blvd., Los Angeles 45, Calif.
600 Old Country Road, Garden City, N.Y.

New Materials

Silane Lubricant

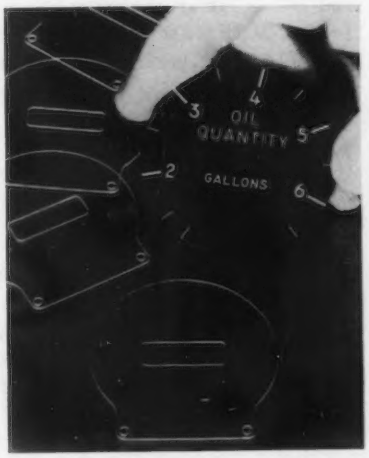
High-temperature lubricant called Diphenylbis-n-Dodecylsilane is a colorless, mobile liquid with good stability and an excellent temperature-viscosity ratio at elevated temperatures. It has no corrosive effects on metal parts, either on storage or when functioning. Applications are as base stock for high-temperature aircraft gas turbine lubricating oil, as an extremely stable high-temperature heat transfer fluid; and as the base stock for lubricating oils and greases where high temperature stability and low vapor pressure are required.—Metal & Thermit Corp.

Circle 118 on postcard for more data

Photosensitive Glass

Photosensitive glass can be precision patterned by chemical machining. It is being used for aircraft dials, and has applications in printed circuits and dielectric spaces. Materials can be produced in volume. Using a photosensitive process, pieces can be accurately patterned at low cost by simple art work. They are non-porous, and dimensionally stable. — Corning Glass Works.

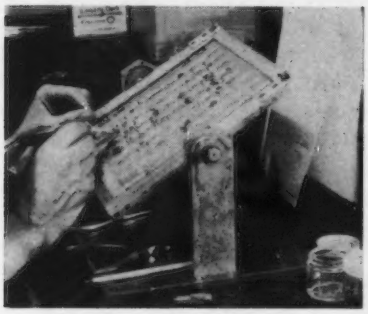
Circle 119 on postcard for more data



New Electronic Products

Universal Circuit

"Universal" circuit card can be prefabricated and adapted to different circuit requirements. This achievement of standardization and prefabrication for computers has long been considered impossible. A working example of this new concept is in the four huge data processing central computers supplied for the Federal Aviation Agency's air traffic control program. Each

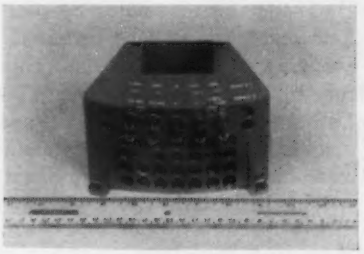


computer card is capable of taking 33 individual modules, and interconnection was made after the final computer design has been firmed.— Librascope.

Circle 120 on postcard for more data

Guidance Inverters

High capacity static inverters are finding use in missile guidance and control. One shown is for Titan. Capacity of devices ranges from 150 to 4000 volt-amps. Efficiency ranges from 65 to 90 per cent depending on power and control required. Phase angle control



is accurate to 0.5 degree. Voltage amplitude is regulated to ±1 per cent from no load to full load.— Delco Radio Div.

Circle 121 on postcard for more data

Micro-Min Enclosure

Micro-miniature transistor enclosure permits component densities on the order of 1,000,000 parts/ft³. This is about 16 times greater than present maximum component density. Enclosure is a flat package measuring 0.125 in. wide, 0.180 in. long, and 0.060 in. high. About 42 such enclosures can be mounted on one square inch multi-element wafer, and still add only about 1/16 in. to its thickness. The design features a cold welded, metal-to-glass, hermetically sealed package providing a minimum seal length of 0.050 in. It will house any type of standard computer transistor. — Philco Corp.

Circle 122 on postcard for more data

Transistorized Tester

Vibration measuring system combines the good thermal characteristics of gas damping with the reliability of the unbonded strain gage. No vacuum tubes are used in the system, thus reducing sensitivity to extraneous vibration. System consists of a miniature unbonded strain gage accelerometer and a transistorized ac amplifier. The transducers may be calibrated statically. The excitation requirement is 28 VDC nominal. The output gain is sufficient to provide 5 V peak-to-peak from 30 to 100 G's.— Statham Inst.

Circle 123 on postcard for more data

8 Gram Transducer

Pressure transducer has only three-fourth in. diam and eight gram weight. The unbonded strain gage transducer was designed for air-borne instrumentation systems or wind tunnels. Pressure ranges are from 10 to 100 psi absolute, 2 to 100 psi gage, and ±2 to ±50 psi differential. Pressure limit is

1.5 times rated pressure without calibration shift and two times rated pressure without permanent damage. Temperature operating is −320°F to +300°F. — Consolidated Electrodynamics Corp.

Circle 124 on postcard for more data

Mission Evaluator

Recording package for use on tactical mission can be used to check

pilot and aircraft performance. The plug-in device requires no additional aircraft wiring. Unit contains a 12-channel oscillograph recorder. It provides for 16 commutated signals (16 bits/sec), 8 commutated channels (8 bits/sec), and 7 channels of electronics (AC/DC VTVM, phase

THE GRAND CENTRAL REPORT

"NITRASOL" GOES INTO PRODUCTION

Performance and Safety Proven

Scientists at Grand Central Rocket Co. have enormously widened the margin of advantage of the solid propellant over liquid, in *practical* application, with development of a new high-energy nitrocellulose - aluminum perchlorate solid propellant named Nitrasol—now in pilot production at GCR.

In March a completely case-bonded, cast-in-place missile motor of Nitrasol was temperature-cycled repeatedly from minus 75°F to plus 165°F and then successfully fired at minus 68°F. Such motors have excellent storage characteristics. They can be stored for extensive periods, then fired at an instant's notice.

These qualifications adequately fulfill the conditions of environmental storing, handling and tactical deployment which the military services would ideally hope to specify but which until now have not been realized in any high-energy propellant.

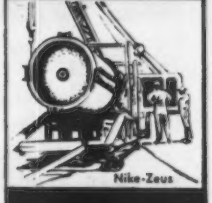
High production rates in a low cost facility make Nitrasol even more attractive. The four ingredients are easily and safely combined; organic nitrate plasticizer-stabilizer solution, fine-particle nitrocellulose, ammonium perchlorate and aluminum particles.

The feasibility of mixing Nitrasol in GCR's Redlands plant and transporting it to any location in the U.S. for subsequent casting in large-volume solid motors is yet another possibility of Nitrasol—perhaps the most promising propellant in existence today.

Positions open for chemists, engineers and solid rocket production specialists.

Grand Central Rocket Co.

P. O. Box 111 Telephone: PYramid 3-2211
REDLANDS, CALIFORNIA



New Electronic Products

detector, xp scale voltmeter). In addition, three channels are available which require only scale resistors.—Hughes Aircraft Co.

Circle 125 on postcard for more data

Rotary Connector

Centrifuge slip ring gives rotating electrical connections for instrumenting components under test. It may also be used for simulated aerodynamic heating. Unit is available with impedance matched circuits for closed loop video. Electrical specifications: 60 Circuits, 51 rated 10 amp, 9 rated 33 amp, 4 contacts each ring. Rings and contacts are precious metal; lead wire is Teflon insulated.—Slip Ring Co. of America.

Circle 126 on postcard for more data

Light DC Motor

Light weight DC motor features a flame quench device. This allows max cooling air to be drawn through the motor while it meets the explosion proof requirements of MIL-E-5272B. Flame quench rings permit greater heat dissipation and a higher output rating for a given motor frame size.

Statistics are: (1) 4.0 hp at 8500 rpm continuous duty, (2) 6.0 hp at 7300 rpm continuous duty, (3) 26.6 VDC, (4) Weight, 18 lb with radio noise filter.—Hoover Electric Co.

Circle 127 on postcard for more data

Diode Boards

Diode boards requiring only four solder connections permit the snapping of diode leads into clips for full wave-bridge circuit. This facilitates diode replacement and eliminates danger of diode failure resulting from soldering heat. —Minarik Electric Co.

Circle 128 on postcard for more data

New Parts and Components

at the WESCON Exhibit

Elapsed Time Indicator

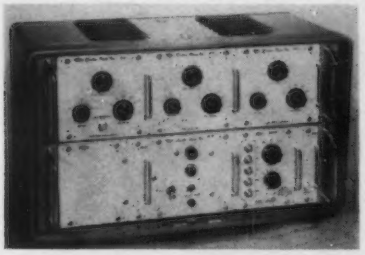
Tiny elapsed time indicator monitors operating-hours of machinery. Weighing 1.8 oz and measuring slightly more than a half inch in diam, the unit nevertheless

has an unusually high numeral readability level, featuring 1/10th-in. white numerals on dull black background.—Bowmar Instrument Corp. Booth 764

Circle 129 on postcard for more data

Pulse Generator

Model 4550A pulse generator is for applications in design and test of ultra high speed pulse circuitry. Although designed primarily for requirements in the megacycle region, the 4550A performs also in the low and medium ranges as a



general purpose test instrument. It is fully transistorized and has been thoroughly field tested for reliability. Its low power consumption allows economical operation and simple integration with other lab equipment. — Electro Pulse Inc. Booth 412

Circle 130 on postcard for more data

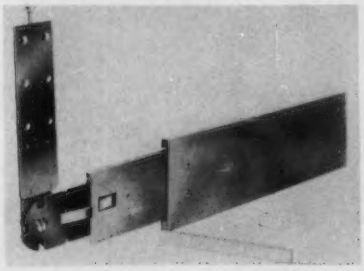
Cuts, Strips Wire

Developed to fill gap between single end stripping and fully automatic operation. The Mark II wire cutter and stripper processes up to 1800 wires per hour. Each wire is cut to length and stripped at both ends in a single operation. Factory assembled and non adjustable cartridge sets enable unskilled operators to make changeovers from one wire to another in less than one minute. Operated by a foot valve, it handles 14 through 30 gage wires and processes most "hard-to-strip" types of insulation. Machine is air actuated.—Technical Devices Co. Booth 114

Circle 131 on postcard for more data

Ball Bearing Slides

Thinline slide mechanisms provide 90 deg up down pivot plus instantaneous quick disconnect



feature within maximum ½ in. width with carrying capacity up to 200 lb per pair. Used in ground system consoles or checkout or test equipment, these slides provide greater chassis accessibility, faster detachment of chassis from rack, and smooth and easy sliding action without harmful play. Slides are of extruded, high strength aluminum alloy. Slide action is ball bearing and roller bearing action. The mechanism provides positive lock-out position.—Jonathan Mfg. Co. Booth 319

Circle 132 on postcard for more data

...We're the Brazing-est!

Not that we want to sound "way out"... but we are! We're way out in front in the brazing field... doing what's considered the finest work in the use of Super Dry Hydrogen and Nickel alloy for brazing aircraft, rocket and missile components.

In addition, many other alloys, like gold, can be used in our Super Dry Hydrogen atmospheres.

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Whatever your brazing needs, use our unmatched experience. Contact our Engineering Department for consultation... no obligation, of course.

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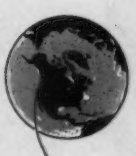

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By

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AMAZING BRAZING

Circle 43 on Inquiry Card

WHAT MORE DO YOU WANT GRAPHITE TO DO FOR YOU?

Graphite has been useful in aircraft and missile problem-solving as a component material in rocket motors, in brazing fixtures for airframe construction, and in other refractory applications.

Further and more advanced uses of graphite in space age progress may well be developing now as part of your design engineering program.

As one of the world's largest producers of high quality graphite, we would welcome having our engineers and technicians work with you on these developments.

May we have the pleasure of hearing from you?

PRODUCTS GLC YOU CAN TRUST

GREAT LAKES CARBON CORPORATION

18 EAST 48TH STREET, NEW YORK 17, N.Y. OFFICES IN PRINCIPAL CITIES

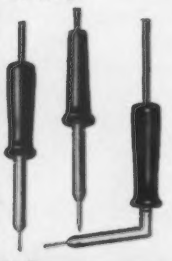
Circle 36 on Inquiry Card

NOW in 50 WATTS for MINIATURE and SUBMINIATURE PRODUCTION SOLDERING JOBS

the *NEW,* American Beauty BANTAM "X" series

Designed with 50 watt input, these fine soldering irons will give greater productivity and do industry's most exacting soldering jobs easier, faster, better. SLOTTED STAINLESS STEEL CASINGS MAKE THE HANDLES REALLY COOL, ending operator complaints. There's no waiting or fumbling with these light, flexible tools — they're always ready. American Beauty soldering irons are known the world over for their dependability, durability and efficiency. Learn more about these fine soldering tools today.

Shown below are other shapes and tip-size irons available in the BANTAM "X" series.



YOU CAN'T BEAT A SOLDERED CONNECTION

WRITE FOR DESCRIPTIVE CATALOG SHEET, FORM NO. 222-CT

AMERICAN ELECTRICAL HEATER COMPANY

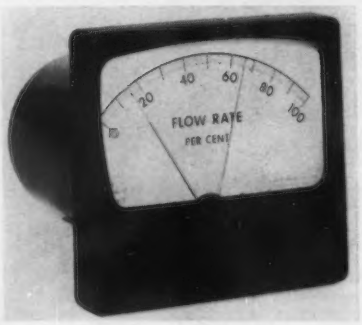
DETROIT 2, MICHIGAN

Circle 37 on Inquiry Card

New Parts and Components

Maximum-Reading Meter

Combining a meter-relay movement and special circuitry instrument shows the highest level reached by an electrical signal. Until reset, the "adjustable" pointer remains at the maximum signal



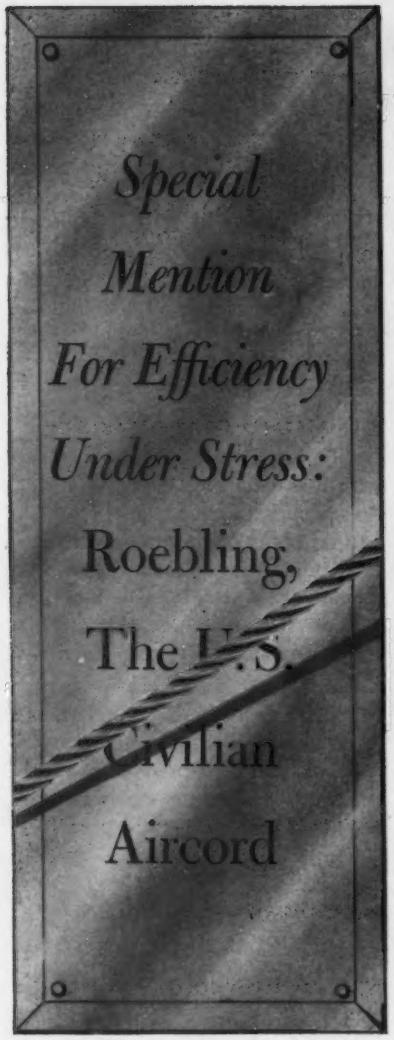
reached over any period of time. The other pointer provides continuous signal indication. Any variable that can be expressed as a electrical signal can be measured with this meter. In most cases, a direct, unamplified signal is used. Meter is available in 0-10 microamperes to 0-50 amperes, or 0-5 millivolts to 0-500 volts, AC or DC.—Assembly Products Inc. Booth 915

Circle 133 on postcard for more data

Miniature Tape-Reader

A punched-tape reader set—including transmitter - distributor, motor, base and cover—is some 40% smaller in size and weight than previous models. Called the Model 28 Miniaturized LXD set, the new smaller tape reader measures 5⅞ x 7½ x 9½ in. It features facilities for sequential (serial) output, hundred - word - per - minute transmission and reduced power requirements. Optional contacts are available for multi-wire output. Models may be had to read 5- or 61 level chadless or fully perforated tape.—Teletype Corp. Booth 2425

Circle 134 on postcard for more data



Roebling Aircord—tinned or galvanized carbon steel—comes to you bearing an unparalleled "research pedigree." It is built and tested to exceed *military* specifications: constructional stretch has been virtually eliminated. Roebling makes Lock-Clad Aircord (aircraft cable with aluminum tubing swaged around it), stainless steel aircord, assemblies with fittings swaged to cable ends, as well as a complete line of slings.

Plane manufacturers and air supply houses interested in the qualities of Roebling aircord assemblies or slings, may address inquiries to Wire Rope, John A. Roebling's Sons Division, Trenton 2, N. J.

ROEBLING

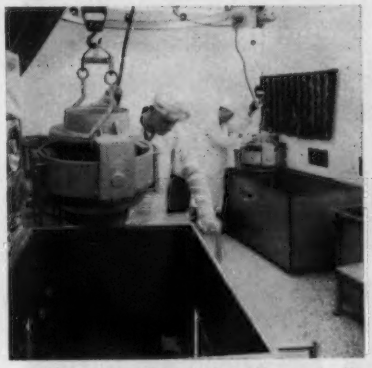
Branch Offices in Principal Cities
John A. Roebling's Sons Division
The Colorado Fuel and Iron Corporation

Circle 30 on Inquiry Card

New for Production

Missile Cleaning

Network of white rooms at major missile bases is available to manufacturers on an independent basis.



The facilities handle missile parts for both airborne components and ground support equipment. They include ultrasonic agitation vats, and high and low pressure demineralized water for rinsing.—Dow Industrial Service, Div. of Dow Chemical.

Circle 135 on postcard for more data

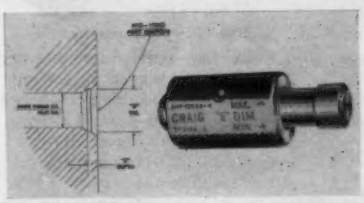
Electronic Tapwelder

Precision electronic tapwelder joins resistance alloy wires of .025 inches to .0007 inches diam at production line speeds. Weld is stronger than parent wire and accurate to one turn.

Unit welds without pressure; hence does not flatten, stretch or distort the wire.—The Hanjohn Co.

Circle 136 on postcard for more data

Gauge



Combination flush pin and go-no go gauge checks AND 10050

AIR He N

COMPRESSION to 12,000 psi

...discharge capacities to 150 scfm

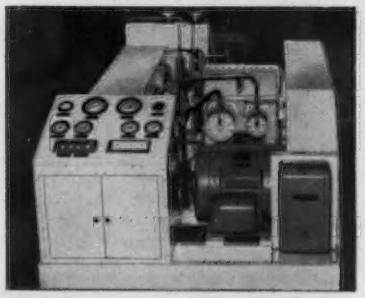
with CARDAIR CENTRAL COMPRESSION SYSTEMS

New Technical Data and Catalog. See offer below.

Cardair Central Compression Systems (completely packaged, semi-portable)—are today handling air and a variety of gases—helium, nitrogen, argon, etc.—at pressures ranging from 4,000 to 12,000 psi with discharge capacities from 50 to 150 scfm. Even hydrogen is being safely compressed to elevated pressures.

Systems can be provided from stock with *guaranteed* purification of delivered gas to —100°F. dew point and less than 4 ppm oil content. Specially engineered systems to meet your particular requirements can be supplied from standard components.

This performance is *demonstrated* by exacting rocket and missile service and continuously growing use by prime contractors, suppliers of missile components and controls, and testing laboratories. It is *backed* by over 20 years of compressor design and application experience.



Model PB-CCS—*One of a wide selection of systems* 4-stage air-cooled Compression System—Pressure Range: 6,000—12,000 psig—Induction: 65 to 135 psig—Capacity: 75 scfm N₂ and Air; 70 scfm He—Guaranteed Gas Purity: —100°F. Dew Point, less than 4 ppm oil content.

FOR YOUR FREE CATALOG, clip this to your signed letterhead and mail to:

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WESTERN STATES DISTRIBUTOR:
General Air Equipment
824 Hollywood Way, Burbank, Cal.

Circle 31 on Inquiry Card

BEST WAY TO SEAL HOLES!
LEE PLUG
Simply place plug in reamed hole. Drive in tapered pin until ends are flush. Controlled expansion causes grooves to "bite" into casting, assures a bone dry seal that withstands pressures up to 40,000 psi. Now widely used on aircraft and missiles, and for pumps, servo valves, regulators, etc.
*Pat. #2,821,323
LEE COMPANY
OLD SAYBROOK CONN
WRITE TODAY FOR COMPLETE ENGINEERING DATA

Circle 38 on Inquiry Card

RUGGED, HEAVY DUTY

FLIGHT LINE TEST CONSOLE

- meets MIL specs
- Certified-welded steel construction
- accepts standard EIA 19" electronic chassis

Available in multiple bays mounted on heavy duty dollies suitable for towing on airfield paving. Heavy duty steel construction permits installation of hydraulic or electronic components of great weight. Consoles accept standard EIA 19" electronic chassis. Swing-up work surface locks in horizontal position for convenient service of chassis or components 'on location.' Cabinet is 51.3" high, 24" or 36" deep. Slope front is angled 10° from vertical.

These features also are available to Customer specs: dust proofing and moisture proofing; filtered or refrigerated air cooling systems; shock absorbing casters with or without locks to prevent rolling; solid or pneumatic tires; lifting eyes or fork lift truck openings; MIL or special finish.

Write for complete data

ORegon 8-7827

ONE SOURCE . . . for VENTILATED RELAY RACK CABINETS, CONTROL CONSOLES, BLOWERS, CHASSIS, CHASSIS-TRAK®, RELATED COMPONENTS

WESTERN DEVICES, INC.

600 W. FLORENCE AVE., INGLEWOOD 1, CALIF.

New for Production

hydraulic contours. Designed for in-process and final inspection of port contours after machining.—Craig Tools Inc.

Circle 137 on postcard for more data

Tracer Stylus

Tracer Stylus sets are for use with 360 deg and 3D duplicating. Available with round nose for ball end mill work, square nose for flat end mills.—True-Trace Corp.

Circle 138 on postcard for more data

Hoist-Tractor

Monorail hoist-tractor weighs 83 lb., pulls loads of 13,000 lb. at speeds up to 60 ft. per minute.

Solid neoprene-tired drive wheel transmits power to underside of beam.—Harnischfeger Corp.

Circle 139 on postcard for more data

Automatic Turret Lathe

New AR (automatic ram) turret lathe adds automatic cycle control to the basic setup of the hand-operated ram type lathe.

Two models available: 4AR

with two inch bar stock capacity and the 5AR with bar stock capacity of 2½ or 4½ inches.—Gisholt Machine Co.

Circle 140 on postcard for more data

Analyzes Threads

Helical Path Analyzer shows both linear and "drunken" deviation from the true helical path of threaded parts. It checks deviations to accuracy of .00003 inches.—Pratt & Whitney Co.

Circle 141 on postcard for more data

Industry Notes

Transportation and Handling of the Saturn Booster

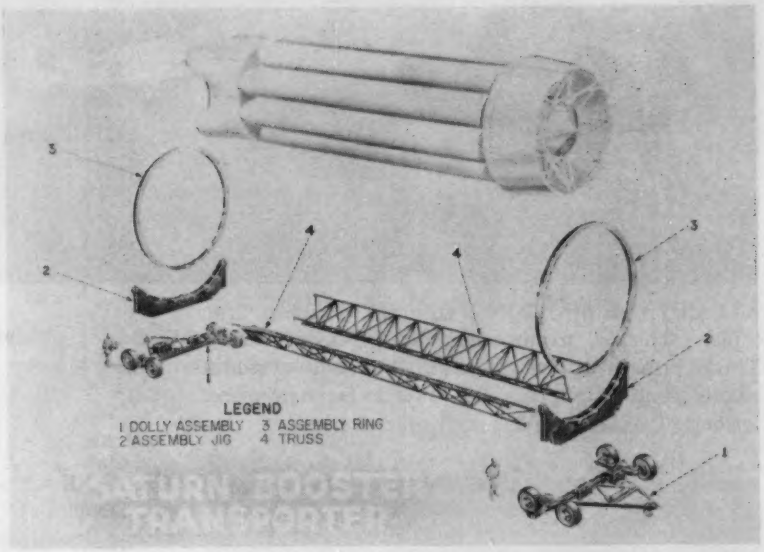
A special ground and water transportation system is being developed to take the Saturn booster from the George C. Marshall Space Flight Center to Cape Canaveral.

System will take the entire booster (body diameter: 21 ft.; length: 80 ft.) over about eight miles of road at Redstone Arsenal, 1470 miles of river, 740 miles of ocean, and about 1½ miles of road at the Cape. Trip is expected to take from two to three weeks with savings of about 60 per cent in costs per shipment over the alternative method of sending each booster tank separately.

Booster consists of a cluster of eight 70 inch diameter tanks, centered around one 105 inch tank. A transporter carries it along the roads, over a ramp at a Tennessee River dock into the cargo compartment of a flat deck barge 180 ft. long by 38 ft. wide. Barge is then towed to Canaveral (see illustration).

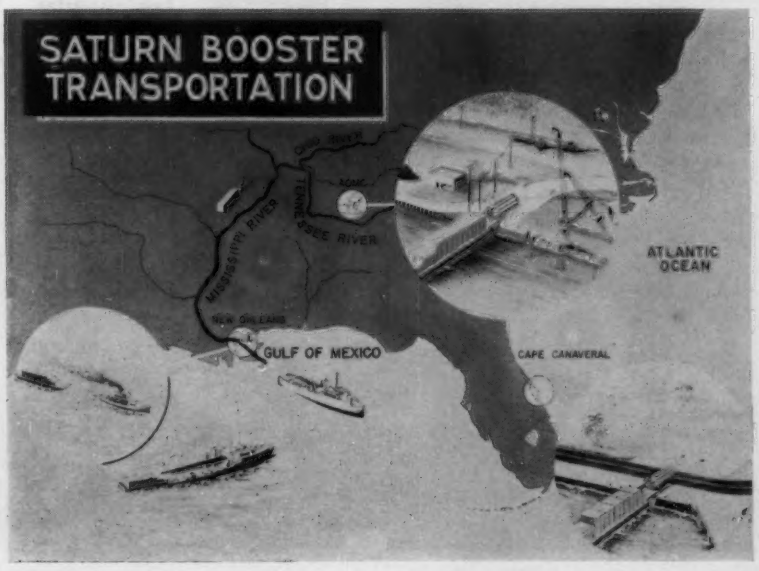
Use of forward and aft assembly jigs as main support for the transporter answers the operational need for an assembly fixture at any location. Major disadvantage of the alternative method of shipping tanks individually was that it would have demanded much additional facilities and equipment both at ABMA and the firing site.

Forward and aft rings give lateral rotation during initial assembly of tanks. Dolly assemblies use eight aircraft tires in all. Tire pressures do not exceed 90 psi. Forward and aft dolly units can be independently steered and controlled.



TRANSPORTER supports assembled booster on forward and aft assembly jigs. Rings on jigs provide lateral rotation for clustering eight 70 in. diam. tanks around central 105 in. diam. tank.

WATER SHIPMENT uses flat deck barge. Complete booster and transporter are towed from Redstone to Canaveral via Tennessee River, Ohio and Mississippi River waterways, and Gulf of Mexico.



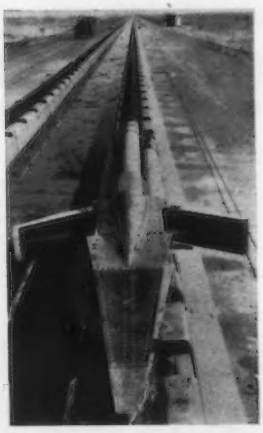
Industry Notes

Ground Support in Pictures

ATLAS TANK SECTION is strapped to mobile steel trailer. "Huskie" tractors built by Brockway Motor Trucks bring it to launch site. Hydraulically-operated wheels along bottom of trailer lower to facilitate plane loading. Two more trailers carry other sections.

GROUND - HANDLING equipment produced for Atlas missiles and boosters by Goodyear Aircraft has new system of trailer unit, erection devices and support units.

LOX TANK is loaded into Douglas C-133 at Long Beach, Calif., for flight to Thor missile - launching base. Vacuum-jacketed tank is 52 ft. long with 9 ft. diam. It is built by Cryogenics Div., Standard Steel Corp., Los Angeles. Firm also provides liquid oxygen tanks for Atlas launching complexes in the U. S.

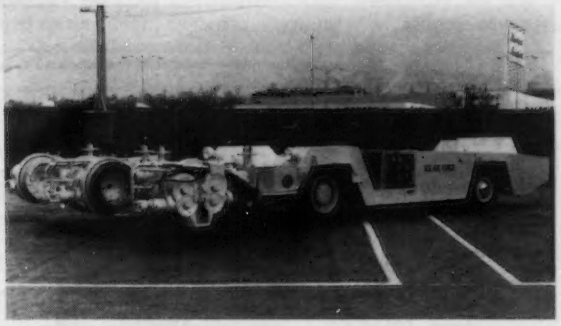


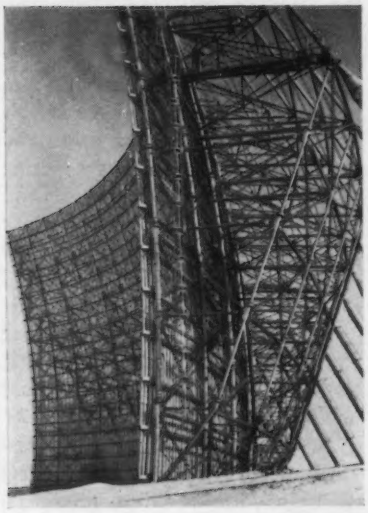
ROCKET SLED at Holloman AFB, N.M. tests inertial guidance system components. Monorail vehicle goes over 35,000 ft. track. It has been stopped from 2688 mph (note braking fins). Sled was designed and built by Norair Div., Northrop Corp. It is 21 in. high, 16 ft. long and is built of steel and aluminum. Fins open at rocket burnout.

ATLAS AIRLIFT in C-133 is new ICBM handling procedure. Here missile goes through enlarged aft doors at field near Convair's San Diego plant. The Military Air Transport Service will fly it to "soft" launch site.

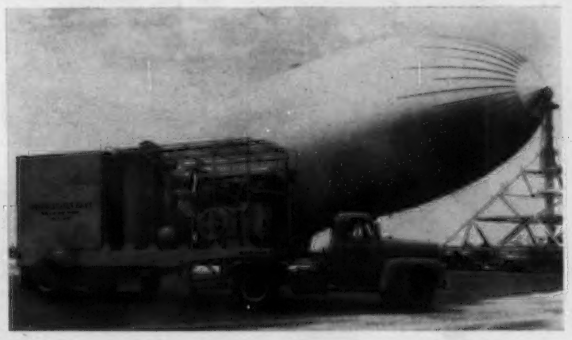
SERGEANT is assembled in field on erector-launcher rig. Picture shows nose section being unloaded from transport trailer (right). These ground support vehicles are of "T-1" alloy steel (U. S. Steel Corp.).

HYDRAULIC WHEEL DRIVE UNIT can move combat-loaded B-52 over ice and snow. Air Logistics Corp. is delivering 35 to the Air Force.



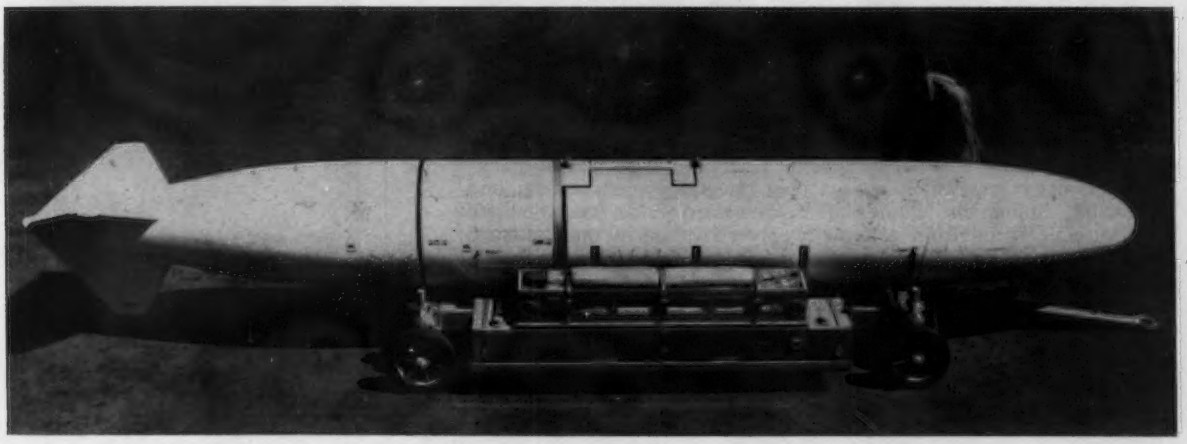


BMEWS 1500-TON ANTENNA REFLECTOR is part of ground-based missile detection system at Thule, Greenland. RCA is prime.



AIRSHIP IS SERVICED quickly at base by van during anti-submarine and early warning duty.

POWER PODS KEEP NAVY'S A3J AND F4H READY for emergency takeoff. Turbine-driven pods can be carried under wings to advance fields. Builder: AiResearch Manufacturing Div., The Garrett Corp.



Industry Notes

Mercury Periscope

Lens cartridge of a periscope will poke through the skin of the Mercury space capsule at intervals during orbit.

The periscope — with lens retracting into the shell on command —has an eight-inch diam. display area. Watching it, a man in orbit receives altitude and attitude information; also relative bearings of sun and moon.

If the capsule's automatic reentry system should not function properly, periscope will help the Astronaut judge the proper moment for firing retrograde rockets for the descent.

Periscope controls are designed for easy operation by a pilot wearing a pressure suit with gloves inflated. He uses reference marks on the periscope face to learn data on drift, altitude (50 to 250 nau. miles), pitch, roll, true vertical, retrograde angle, and field of view of his earth-sky camera.

Looking into the periscope screen, the observer sees a clear display of the earth. When the earth is centered on the display screen, the outer part of the circular view shows the earth's horizon circle, and the center of the view represents the end of a vertical line to the center of the earth.

Set for low power magnification the periscope presents a single-field, horizon-to-horizon view. With high power magnification, the observer sees two fields at the same time: a low power outer view of the earth's horizon (130 to 180 deg field), and a high power center view covering a 19 deg field around the vertical. Between the two views is a dark ring about 3 deg wide.

One unusual optical feature of the Mercury capsule periscope is "sandwich" mirror design. These consist of two thin glass plates. Cylindrical glass disks are cemented in a pattern between them.

The Electro-Optical Div of Perkin-Elmer Corp. is producing twenty-one Model 133 satellite periscopes for McDonnell Aircraft, Mercury prime.

PERISCOPE is shown mounted in test rig, where it receives final optical adjustments.

Precision Saw With Air Clamps Makes Clean Cuts..Reduces Waste & Machining

FOR
Stainless
Aluminum
Magnesium
Copper
Glass

Rough edges left from shearing and inaccurate saws pile up needless machining bills . . . plus the cost of wasted metal. With this new Ty-Sa-Man 144-BD Saw, adjustable air clamps hold metal down while the saw travels down the machined transverse rail, delivering cuts with smooth edges to amazing tolerances. Cut parallel strips . . . handle difficult jig fixture work with this self-contained saw which has its own integral cooling system and tank. Among its features are a calibrated guide fence, infinite variable speed from zero to twenty FPM, push-button control and 15 HP motor.

Ty-Sa-Man
SINCE 1885

Write for FREE BROCHURE
TY-SA-MAN Machine Co., Inc.
1135 White Ave., Knoxville, Tenn.

Circle 48 on Inquiry Card

Minuteman Rail-Car Completing Shock Tests

A "pre-prototype" Minuteman-launching railroad car is under test to check out its vertical, longitudinal and transverse cushioning system.

The shock tests are at the Berwick, Pa., plant of the American Car and Foundry Div., ACF Industries Inc. Tank and other containers in the flatcar are filled with water, sand or concrete to simulate weight distribution of the proposed missile-loaded car.

Impact tests roll another car down a ramp into the Minuteman car at speeds up to 10 mph. Gauges and a high-speed camera record velocity and distance traveled by test car after impact.

For testing purposes, car is exactly the same as the finished Minuteman car. However, its appearance is much different from final product.

Car's undercarriages are called the largest and most advanced ever built. Each has six wheels (three axles). Their air-coil spring suspension isolates the shock of impact and permits the cargo to ride in shockproof condition.

ACF and American Machine and Foundry Co. were selected as a team by Boeing Airplane to design and develop the basic missile car and a command car to house support equipment.

THREE-WAY STRETCH against vertical, longitudinal and transverse shocks is special feature of Minuteman launch car "pre-prototype."

FPD PROFESSIONAL EMPLOYMENT NEWS

PUBLISHED BY THE FLIGHT PROPULSION DIVISION OF GENERAL ELECTRIC IN CINCINNATI, OHIO / **AUGUST, 1960**

FPD NEWS offers latest information on openings throughout the Division to interested engineers and scientists. Technical information and news relating to current projects will also appear from time to time in this column.

New Fan Burner Engine Proposed for 2000 MPH Speed Range

Recently the general manager of FPD, J. B. Montgomery, announced that 2000 mph military and commercial transport aircraft can be powered efficiently and reliably by a new type of jet engine which FPD can produce whenever it is needed.

Called a fan burner, its principle involves burning fuel in the exhaust of a fan mounted directly behind the basic jet engine. From an engineering point of view, the manager indicated it would also be possible to apply this principle to an existing engine such as G.E.'s J93, powerplant destined for the B-70.

This development is an interesting example of Flight Propulsion Division's gearing up for the unique requirements of commercial jet powerplants over the next decade. In this area, the Division is "leading from strength"—basing new programs for industry on its impressive and continuing record in combat aircraft propulsion.

Broader Scope Envisioned For New FPD Jet Engines

Artist's conception of the hydrofoil craft under development by Grumman exemplifies FPD's emphasis on continually broadening the scope of engineering and product applications. Craft will be powered by FPD Model 240 turboshaft developing 20,000 shp. Cutaway on illustration indicates approximate position of engine.

Immediate Opportunities in Military & Commercial Jet Engine Development and Design

Application Engineering
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GENERAL ELECTRIC

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Another "impossible" job done by the Airbrasive...

...cutting tungsten

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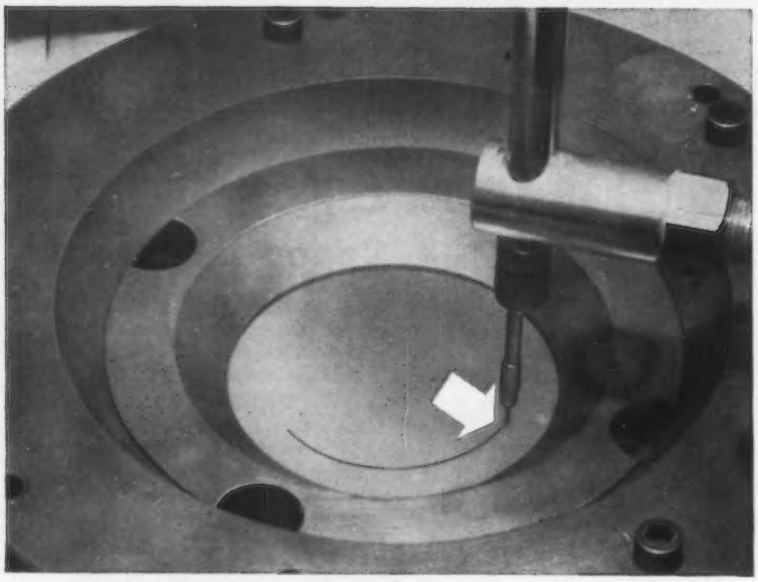

Comstock & Wescott found: "The most practical way to cut tungsten sheet without cracking!"

Here was a tricky job for the Airbrasive. Comstock & Wescott, Inc., Development and Research Engineers, Cambridge, Massachusetts, had to cut 0.005" thick tungsten sheet into circular components for missile systems. Mechanical cutting methods caused the brittle tungsten parts to crack. *The Airbrasive did it successfully!*

How does the Airbrasive work? It obtains its precise cutting action from a high-speed jet of dry gas and abrasive particles that quickly cuts, slices or abrades, as needed, almost any hard brittle material... germanium, silicon, glass, alloy steels, ferrites, mica, ceramics and others.

Important too... the cost is low. For under $1000.00 you can set up your own Airbrasive cutting unit!

Send us samples of your "impossible" jobs and we will test them for you at no cost.

SEND FOR BULLETIN 6006
... complete information.

S. S. White Industrial Division
Dept. 18A, 10 East 40th Street, New York 16, N. Y.

Industry Notes

Business Moves

Librascope Div., General Precision Inc. is operating a new military sales program because of "the growing importance of digital computers as components of defense systems."

The Marquardt Corp. is now running a Special Projects Lab at Rockville, Md., for developing small electronic security equipment.

The Bendix Corp. has expanded its aircraft-missile support equipment activities with Bendix Support Equipment-Teterboro (N. J.) and Bendix Support Equipment-South Bend (Ind.)

U. S. Steel Corp. has issued its first license for casting of its "T-1" alloy. Licensee: Alloy Steel & Metals Co. Possible use: missile launcher castings.

New Facilities

Metrolonics Inc. is operating its independent standardizing lab for calibrating precision instruments. Firm plans labs for hydraulics, electronics, microwave, optics, and infra-red standards.

Thompson Ramo Wooldridge Inc. is conducting materials research and development at its new Colwell Engineering Center—first phase of a $5-million R&D facility.

Aeronutronic Div., Ford Motor Co., is building a 120,000 sq. ft. building at Newport Beach, Calif., for its Tactical Weapon Systems Operations.

General Electric's Light Military Electronics Dept. recently unveiled a million-dollar "Advanced Electronics" R&D facility in Ithaca, N. Y.

Electronic tube-aging tester has been operating at Boeing-Wichita. Boeing estimates technique has reduced down-time due to tube failure by 40 per cent.

ballistics with statistics

Behind the launching pad lie years of statistics.

And years of statistical specialization have given Wall tubing reliability in meeting the critical test. Exhaustive testing assures that Wall Tube's stainless steel, nickel and nickel alloy tubing will be of the highest quality.

Before you procure small diameter tubing of any grade, let a Technical Sales Representative demonstrate Wall Tube's know-how—that developed from demanding application.

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Stainless Steel—Welded and Cold Drawn—1/8" OD to 3.32" OD; .083 to .008 walls. Seamless—5/8" OD to 3.32" OD; .049" to .008" walls. Nickel and nickel alloy—seamless, 5/8" OD to 3.32" OD; .049" to .008" walls.

WALL TUBE AND METAL PRODUCTS CO.

NEWPORT, TENN.

Circle 33 on Inquiry Card

R & D Briefs

Segmented solids being manufactured in experimental quantities at United Technology Corp. NASA contract calls for design, fabrication and testing of three conical-shaped, segmented solid propellant rocket engines.

High-impulse propellant developed at Thiokol-Elkton for the Falcon missile has been successfully fired in rocket engines at temperatures ranging from −85 to +300° F.

Lunar water supply may be extracted from volcanic rock through solar energy process. Aero-Space Laboratories of North American Aviation's Missile Div. is testing such a process.

Hybrid rocket is being explored at Aerojet-General under Navy contract. It would employ liquid oxidizer which would be sprayed into core of solid fuel.

Flight breadboard system, under study at Turbo Div. Sundstrand Corp., could be attached on boom away from craft or could be part of craft.

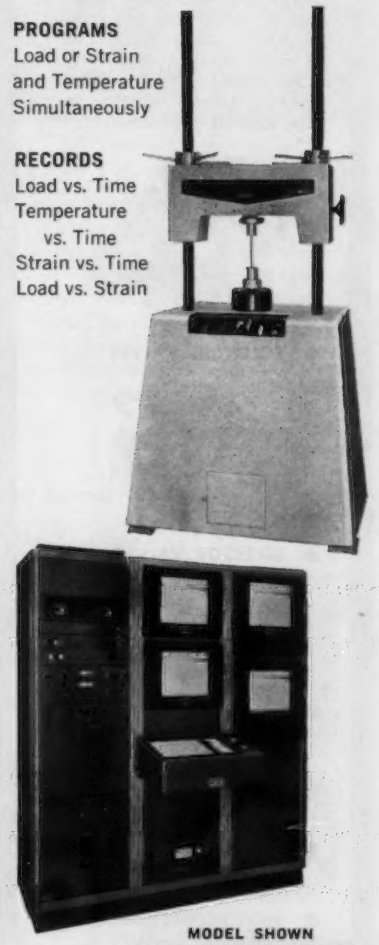
ROTATING SUPPORT TOWER holds scale model of B-52G at Boeing Airplane's Wichita Div. Tests measure radiation patterns given off by aircraft's antennas. Tower is made of dielectric material lest it affect aircraft's radiated signals. Rail-mounted platform is operated from control building.

A thermal-dynamic

MATERIALS TESTING SYSTEM

PROGRAMS
Load or Strain and Temperature Simultaneously

RECORDS
Load vs. Time
Temperature vs. Time
Strain vs. Time
Load vs. Strain



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Loading Capacity: ± 10,000 lbs.
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Take the high response characteristics of electro-hydraulic servo valves and loading mechanisms, add the convenience of pencil-line program plotting, apply the precision of electronic load and temperature control and recording techniques, and you have the basis of this new testing system designed with just one thought in mind — to advance the art of materials testing.

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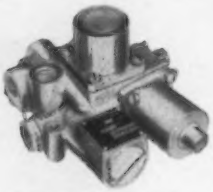
AND
PERFORMANCE
are our main products

First, imaginative design; then experienced thoroughness through development, tooling, production, assembly and tests, all under strict quality control in an unusually well equipped plant . . . we can help you solve your special problems . . .



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PHONE: MYRTLE 2-2711

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Industry Notes

Production Techniques

The Garrett Corporation's AiResearch Manufacturing Co. has developed new technique of handling liquid nitrogen. Transfer lines carry it at minus 320°F over distances exceeding 25 ft. Exterior remains frost free and may be manipulated with bare hands.

Cornell Aeronautical Laboratory has demonstrated its Mark I "perceptron." This electromechanical research device has a "sensory unit" of photo cells which views a pattern such as letters of the alphabet. Machine's memory and response units can automatically identify patterns.

Boeing Airplane has begun regular operation of new hypervelocity wind tunnel—largest privately owned facility of its kind in the world. The "hotshot" is designed to operate in the speed ranges from mach 10 to mach 27, at temperatures up to 14,000 deg Fahrenheit. It simulates altitude conditions up to 260,000 ft.

Contracts

The American Machine and Foundry Co.—$81,567,000 for 36 Titan launching systems.

Raytheon Co. — $56,730,832 total Army contracts for Hawk missiles and ground support equipment; $23,600,000 from the Bureau of Naval Weapons for continued Sparrow III production.

The Martin Co.—$18,853,460 in total Army contracts for the Lacrosse missile system; $3.3-million for additional Bullpup production.

Hughes Aircraft — $9,448,228 from the Army to the Ground Systems Groups for AN/MSQ-18's, used in the Missile Monitor system; $7,500,000 from the Navy for producing Polaris guidance systems.

Whether shooting for the moon or pinpointing an ICBM in the Atlantic, success or failure already has been determined before the button is pushed. Hit or miss depends upon the *reliability* of men, component parts, and support equipment.

Reliability of Hokanson missile support air conditioning has been proven in support of the Snark, Polaris, Thor, Titan, Minuteman, and Atlas programs. Hokanson also has demonstrated its ingenuity by solving new and unusual air conditioning design and performance requirements.

If you have a missile air conditioning problem, let Hokanson solve it. Write today for our latest brochure.

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Hokanson

AIR CONDITIONING
C. G. HOKANSON COMPANY, INC.
2140 Pontius Avenue
Los Angeles 25, California

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Aerojet-General Corp. — $2.5-million Navy contract for Tartar solid propellant motors.

Ryan Electronics — $34,000,-000 finalized Navy contract for AN/APN-122 (V) Doppler navigation systems and support equipment.

North American Aviation—$9,-100,000 to the Columbus Div. for fabricating and assembling the 600 ft diam. aluminum "dish" for the Navy's Sugar Grove, W.V. radio-telescope.

Aerospace Log

June 9—Pershing firing a "complete success." Dummy second stage.

June 10—Army announces first destruction of one guided missile by another—Nike Hercules destroys Corporal.

June 15—Saturn booster tested in full duration firing—122 sec.

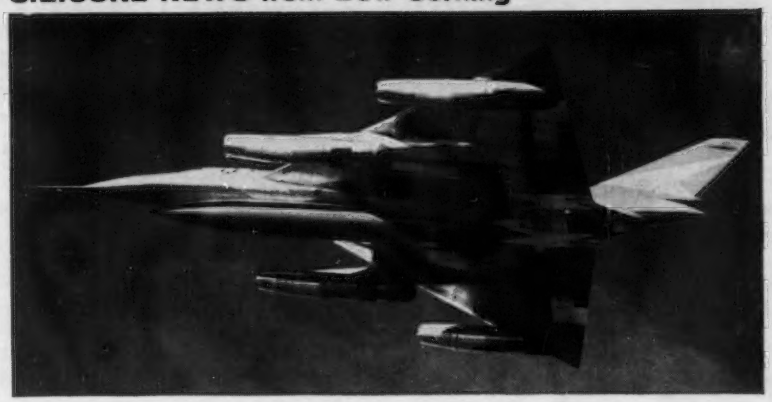
June 22—Two satellites orbited at once by Thor-Able Star. One is Transit IIA navigational satellite; other measures solar radiation. Transit is 3 ft diam, weighs 223 lb. It was connected to 20 inch, 42 lb radiation satellite by cable, clamp and explosive bolts. Separation came shortly after orbiting began.

June 24 — Titan makes 5000 mile flight down Atlantic Missile Range from Cape Canaveral.

July 5 — Tass reports Soviet multi-stage rocket reached 8078 miles into mid-Pacific.

ATLAS SILOS use these air spring support cylinders to keep floor level and provide a spring cushion. Links (front) connect with floor. Boeing-Wichita produces cylinders for the Army.

SILICONE NEWS from Dow Corning



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A simple "short" due to insulation failure can ground or make impotent the B-58 Hustler, this nation's present promise of devastating reprisal. That's why Convair engineers specified Silastic®, the Dow Corning silicone rubber, as the insulation for power and control cable.

One moment this super-sonic guardian is streaking through the arctic cold and ozone-containing atmosphere above 50,000 feet . . . minutes later it may be standing in the oven heat of a desert landing strip . . . tough environments for any rubber insulating material — except Silastic.

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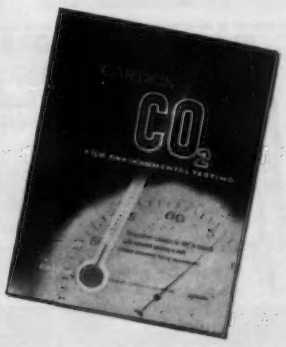

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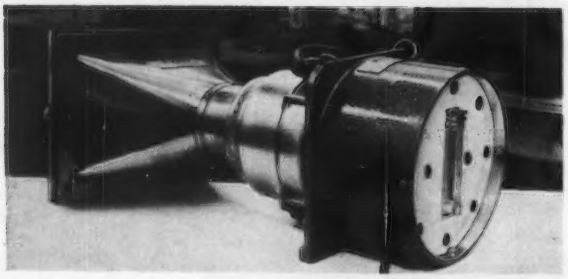

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Staplex Air Samplers are being used every day to solve the needs of such companies as: Convair, Curtiss-Wright, Lockheed Aircraft, North American Aviation, Pratt & Whitney, Glenn L. Martin and others. Tell us about *your* air sampling problem.

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Send me complete information on the Staplex Air Sampler.

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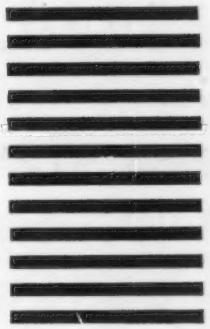

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IMPORTANT • MUST INFORMATION

YOUR NAME .....**TITLE** .....

COMPANY .....

PLANT ADDRESS .....

CITY .....**ZONE**.....**STATE**.....

Please check in A & B below which best describes:

A. Your Job Function

....1. Management
....2. Design & Engineering
....3. Production
....4. Procurement

B. Type of Plant or Facility

....1. Airframe
....2. Propulsion
....3. Electronic Systems & Parts
....4. Mechanical Systems & Parts
....5. Raw & Processed Material
....6. Engineering & Research Services
....7. Military & Government Facilities
....8. Parts & Supplies
....9. Plant or Test Equipment
....0. Other

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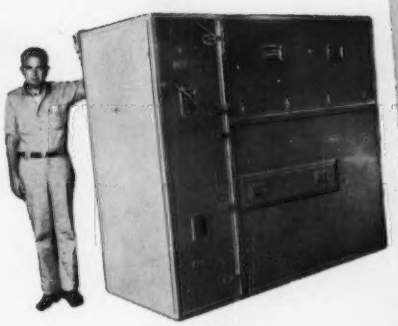
Skydyne, Inc

CASE HISTORY

The total background of Skydyne's 20 years of pioneering in the design and manufacture of transit and operational cases, consoles and benches is expressed in every unit produced — whether specially engineered, or part of a modified standard line.

SANDWICH MATERIAL FIELD AND MOBILE TRANSIT CASES

Skydyne's "Unistruc" construction of sandwich type transit cases produces completely bonded units of minimum weight and maximum strength. Individually engineered cases are particularly effective for use with ground support and other military equipment, and are designed to meet specifications MIL-T-945/A, MIL-T-4734, MIL-T-21200 and MIL-C-4150/E, as required. They assure greatest possible protection of sensitive equipment under widely varied circumstances and environment.



FEATURES

- Integrated structural frame
- Panels bonded to frame members
- No limitation on size or design
- Sandwich panel types to meet individual requirements
- Shock absorbed by entire case.

MOLDED FIBERGLASS HAND PORTABLE INSTRUMENT CASES

Skydyne molded fiberglass hand portable instrument cases are available in 16 standard sizes — each capable of modification to meet individual requirements. Interior packing or mounting devices are custom-designed for protective cushioning. Molded fiberglass cases were developed by Skydyne to house and protect all types of portable optical, electric and electronic instruments and equipment. Cases meet all applicable MIL-T-945A and MIL-T-108C specifications

FEATURES

- Standard sizes, which can be modified for specific uses
- Durable material — waterproof and oil and acid resistant
- High strength to weight ratio
- Corner impact resistance
- Molded in color — no surface finish required

Send us your specifications for estimate.

SKYDYNE — SCIENTIFICALLY ENGINEERED TRANSIT AND OPERATIONAL PACKAGING

MINIMUM WEIGHT Skydyne Inc MAXIMUM STRENGTH

Skydyne, Inc

River Road, Port Jervis, New York

Circle 2 on Inquiry Card

YOU SAVE WITH CLEARING PRESSES

With a bottom drive press, the main floor is cleared for better material handling, increased safety and improved appearance. The lower level simplifies scrap removal and equipment maintenance.

WITH A LINE LIKE THIS...OR A LINE OF TORC-PAC O.B.I.'s—CLEARING PROVIDES THE ULTIMATE IN METAL FORMING EFFICIENCY

Clearing is now building a line like the one above. Presses like these equipped with moving bolsters and the latest features and control devices (as shown at right) are the way to increase profits and production by combatting rising material and manufacturing costs.

Undoubtedly, your production problem is different from the one solved by the press line above. However, whatever the problem—whatever the type or size of press equipment, feeding equipment and dies are best for you—you can rely on Clearing for the most effective solution. Call on Clearing at any time.

Bulletins on Moving Bolster and Bottom Drive Presses are available now.

USI Clearing

DIVISION OF U. S. INDUSTRIES, INC.
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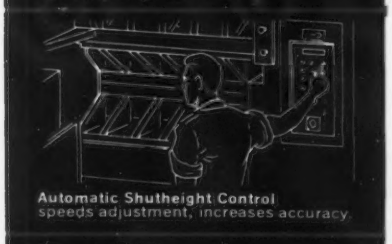
Circle 3 on Inquiry Card

360° Limit Switch speeds changeover time.



Automatic Shutheight Control speeds adjustment, increases accuracy.

Hydraulic Overload Protection increases safety.

Look for the CLEARING NAME on these products

Mechanical Presses • Hydraulic Presses • Torc-Pac O. B. I. Presses • Axelson Lathes • Harrison Lathes • Special Equipment for Aircraft & Missiles Mfg. • Dies • Torc-Pac Drives